# MONTHLY WEATHER REVIEW.

Editor: Prof. Cleveland Abbe. Assistant Editor: Cleveland Abbe, jr.

Vol. XXXVII. FEBRUARY, 1909. No. 2

The Monthly Weather Review summarizes the current manuscript data received from about 3,500 land stations in the United States and about 1,250 ocean vessels; it also gives the general results of the study of daily weather maps based on telegrams or cablegrams from about 200 North American and 40 European, Asiatic, and oceanic stations.

The hearty interest shown by all observers and correspondents is gratefully recognized.

Acknowledgment is also made of the specific cooperation of the following chiefs of independent, local, or governmental services: R. F. Stupart, Esq., Director of the Meteorological Service of the Dominion of Canada; Señor Manuel E. Pastrana, Director of the Central Meteorological and Magnetic Observatory of Mexico; Señor Camilo A. Gonzales, Director-General of Mexican Telegraphs; Capt. S. I. Kimball, General Superintendent of the United States Life-Saving Service; Commandant Francisco S. Chaves, Director of the Meteorological Service of the Azores, Ponta Delgada, St. Michaels, Azores; Dr. W. N. Shaw, Director of the Meteorological Office, London; Maxwell Hall, Esq., Government Meteorologist, Kingston, Jamaica; Rev. L. Gangoiti, Director of the Meteorological Observatory of Belen College, Havana, Cuba; Señor Luis G. y Carbonell, Director, Meteorological Service of Cuba, Havana, Cuba; Rev. José Algué, S. J., Director of the Phillipine Weather Bureau, Manila; Maj. Gen. M. A. Rykachef, Director of the Physical Central Observatory, St. Petersburg, Russia; Carl Ryder, Director, Danish Meteorological Institute, Copenhagen, Denmark.

As far as practicable the time of the seventy-fifth meridian is used in the text of the Monthly Weather Review.

Barometric pressures, both at land stations and on ocean vessels, whether station pressures or sea-level pressures, are reduced, or assumed to be reduced, to standard gravity, as well as corrected for all instrumental peculiarities, so that they express pressure in the standard international system of measures, namely, by the height of an equivalent column of mercury at 32° Fahrenheit, under the standard force, i. e., apparent gravity at sea-level and latitude 45°.

## FORECASTS AND WARNINGS.

By Prof. E. B. Garriott, in charge of Forecast Division.

There was a remarkably uniform progression of high and low barometer areas over the Northern Hemisphere during February, 1909. In the United States the interval between centers of areas of low barometer, or general storms, averaged about four days. The Asiatic area showed crests above 31.00 inches in the first and third decades of the month, with comparatively low pressure from the 12th to 17th, and a gradual decrease of pressure after the 20th to a minimum for the month below 30.00 inches on the 27th and 28th. Variations in pressure over this great continental area are associated with general weather changes that occur over the United States one to two weeks later. It will be observed in the present instance that following the prevailing high pressure of the first two decades of the month over Siberia temperature averaged unusually high in the United States, and that the depression over that region at the close of February was followed by a period of unseasonably cold and stormy weather over the United States during the second week in March.

High barometric pressure over the Asiatic area is usually attended by abnormally low pressure over extreme northwestern Europe, and during the opening days of February the barometer in the Iceland area fell to a reported minimum of about 28.60 inches on the 2d. During this period heavy rains in the river districts of Germany caused enormous flood damage. The barometer again fell below 29.00 inches over Iceland on the 9th, and at the close of the month, when the barometer was low over Siberia, pressure was abnormally high over Iceland and severe winter weather was experienced generally in Europe.

In the United States the month opened with high barometric pressure east of the Rocky Mountains, and decreasing pressure on the Pacific coast. From the 2d to 6th a disturbance of marked strength crost the country, attended by general precipitation and followed by a cold wave. The following special forecast was issued on Saturday, the 6th, in connection with a storm that advanced from the Pacific to the Atlantic coast from the 6th to the 10th:

A storm that now occupies the north Pacific coast will move southeastward over the Rocky Mountains Sunday, and then eastward over the Plains States Monday and Tuesday, and reach the Atlantic coast about Wednesday, attended by snow in middle and northern districts, and followed by a cold wave that will appear over the Northwestern States Sunday or Monday, advance over the central valleys and Lake region Monday and Tuesday, and reach the Atlantic States about the middle of next week.

The following are among the press comments that have been made regarding this forecast:

Fort Smith, Ark., Times, February 8, 1909:

On Saturday there was sent out from the Washington Weather Bureau headquarters a general forecast reporting a storm disturbance on the northern Pacific coast that would advance southeast, followed by a cold wave. They made good. The Monday morning chart indicated that the storm advanced over the Rocky Mountain region accompanied by snow or rain which covered the whole Mississippi Basin. Following it an area of high barometer is sweeping down from the north, which is accompanied by a fall of as much as 36° in temperature. * * *

Courier-Post, Hannibal, Mo., February 9, 1909:

* * * The storm is the one predicted from the Washington Weather Bureau as early as last Saturday, and the prediction has proven remarkably accurate for such a long time ahead. It is central to-day over Iowa, where it is very pronounced. Heavy snows are predicted for the northwestern part of the State, and strong gales. The zero line has been pushed down into northern Kansas. * * *

Commercial Tribune, Cincinnati, Ohio, February 11, 1909:

Within a few days the Weather Bureau has come up to all expectations. As early as last Monday the signs indicated rain and snow, and Tuesday morning we were told to look out for rain, snow, and much colder weather on Wednesday. Everything came to pass. The reason for calling attention to this fulfilment of prophesies grows out of the fact that there are countless thousands who find fault whenever there is a little slip up. As a rule the predictions are quite accurate and there has been a distinct improvement over other years. In short, the business is beginning to rest more nearly upon a scientific basis, and improvements and observations which are to be expected in the future will make this branch of the Government one of the most important, not to the few, but to many millions. * * *

Another depression from the 7th to the 10th, and from the 11th to the 16th a severe storm, attended by heavy precipitation and by heavy sleet and snow, moved northeastward over

the country from the States of the Missouri and upper Mississippi valleys over the Lake region, Ohio Valley, New England, and northern portions of the Middle Atlantic States. Following this disturbance a cold wave carried temperature below the freezing point along the Gulf coast.

The Leader-Democrat, of Springfield, Mo., of February 15, 1909, comments, editorially, regarding this storm and cold wave:

Along the middle of last week when the sun was shining and little birds twittering Uncle Sam said he saw a rather fierce blizzard in the Rockies and he was certain it had packed its belongings and expected to arrive in Springfield and vicinity about Sunday. Naturally we gave the matter little attention, depending upon the fine Italian hand of our Ozark weather to circumvent any such plot. Nevertheless Sunday came and with it one of the worst blizzards for a long time. Uncle Sam's weather boys are becoming wiser all the time. It has only been within the past few months that they have attempted to forecast more than forty-eight hours ahead. Now they can do pretty well for a week in advance.

Disturbances advanced eastward over the country from the 15th to the 19th, and 20th to 24th. The latter disturbance was attended by heavy snows in the northern Lake region, and by heavy rains that initiated floods in the Ohio River and tributaries and in rivers and streams in the east Gulf States.

### BOSTON FORECAST DISTRICT.*

[New England.]

The month was warmer than usual and precipitation was excessive. Snowfall was light for the season and at the end of the month the ground was generally bare over the southern half of the district. An unusually severe sleet storm occurred in central and northern portions on the 16th. Storm warnings were ordered on the 6th, 7th, 14th, 16th, 19th, 20th, 24th, and 25th, and high off-shore winds for which warnings were not ordered prevailed along the coast on the 10th, but fortunately without damage or delay to shipping.—*J. W. Smith, District Forecaster.*

### NEW ORLEANS FORECAST DISTRICT.*

[Louisiana, Texas, Oklahoma, and Arkansas.]

Warm weather for the season prevailed and precipitation was in excess in Louisiana and Arkansas, and deficient in Oklahoma and Texas. A cold wave occurred over the northern portion of the district on the 8th and 9th and another cold wave of marked severity covered the district from the 13th to to the 15th, when minimum temperatures of 26° to 28° were recorded along the Gulf coast. All warnings were justified and no severe weather conditions occurred in the sugar and trucking regions without warnings. In commenting on the cold weather of the 14th and 15th the Daily Picayune, of New Orleans, La., of February 16, says:

When it is taken into consideration that such low temperatures are of such rare occurrence so far south, the specifying almost to the exact degree of temperature that would be recorded in every portion of so large an area shows that weather forecasting under Chief Moore's management of the Bureau has reached a remarkably high degree of accuracy, not only as to the extent of the cold, but also as to the place, the time, and the degree of cold. Such forecasts are the rule when conditions call for them, and the exact verification of the warnings in this case is not exceptional. When the public receives the Weather Bureau warnings advising them what temperature to expect they take the action which such conditions call for. The stock farmer shelters his herds; the sugar planter protects his sugar cane in the spring and his matured crop in the autumn, on the advice of these warnings. The orange growers and the truck and berry growers all are governed by these forecasts in saving their crops from injury. Every intelligent producer of any crop has learned the degree of temperature which injuries his product, and with the accurate and timely forecasts of the Bureau at his command, he successfully covers his crops thru the abnormally cold spells which occasionally visit the Gulf region, and in this way the Weather Bureau saves to the people of this part of the country millions of dollars annually. It enables the grower to occasionally protect valuable and remunerative crops which would otherwise have to be abandoned.

—*I. M. Cline, District Forecaster.*

### LOUISVILLE FORECAST DISTRICT.*

[Kentucky and Tennessee.]

The month was warmer than usual, and there were no very low temperatures, except the night of the 1st, when zero was reached at a few places in Kentucky. Precipitation was heavy, the amount being two or three times the normal in Kentucky and from 60 to 75 per cent in excess in Tennessee. Extraordinarily heavy and general rains on the 22d, 23d, and 24th caused destructive floods, especially in the smaller streams. Cold-wave warnings were issued on the 8th, 9th, and 14th in advance of decided falls in temperature.—*F. J. Walz, District Forecaster.*

### CHICAGO FORECAST DISTRICT.*

[Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, and Montana.]

Temperature was above the seasonal average thruout the district. Warnings were issued well in advance of a cold wave that advanced eastward and southward from the British Northwest Territory from the 7th to 10th. A second cold wave appeared in the British Northwest the morning of the 11th. It gradually extended over northern and western portions of the district, but its movement farther was retarded by a storm which developed in the southwest. This storm, in fact, was the principal one of the month. It caused heavy precipitation, much of it in the form of snow and sleet over a considerable portion of the district, with accompanying high winds. Warnings for heavy snows were issued to threatened localities, and cautionary advices were sent to the open ports on Lake Michigan. Another cold wave appeared in the northwest on the morning of the 23d, as an extensive storm approached the central valleys from the southwest. This storm caused extensive precipitation, especially heavy snow, in the northern Lake region, for which warnings were issued. As the storm past eastward over the Lake region a cold wave followed in the rear, but only moderately low temperatures occurred. Warnings for the cold wave and accompanying high winds, in addition to the snowfall warnings above referred to, were issued well in advance. No other storms or cold waves of consequence occurred during the month.—*H. J. Cox, Professor and District Forecaster.*

### DENVER FORECAST DISTRICT.*

[Wyoming, Colorado, Utah, New Mexico, and Arizona.]

The most conspicuous feature of the month was the almost continuous snowfall in the mountains from the 5th to 23d. The snow, altho not especially heavy was frequently accompanied by high wind which caused much drifting and interfered seriously with mountain travel. This stormy period was, in the mountains, preceded and followed by severe cold. Over the Plateau the temperature changes were comparatively slight and there was no general cold wave. The weather of the Plains region on the contrary was decidedly changeable, and cold waves crost the northern half on the 8th, 14th, and 23d, followed by moderately heavy falls of snow. The changes were all forecast, and special warnings were issued for the last two.—*F. H. Brandenburg, District Forecaster.*

### SAN FRANCISCO FORECAST DISTRICT.†

[California and Nevada.]

The month opened with generous rains thruout California, and heavy snows in the mountains and high southerly winds along the coast. During the first decade the weather was almost continuously rainy. Floods caused much damage in the valleys and there were numerous washouts along the southern coast. During the second decade storms appeared to approach the coast farther south than usual. Rains were frequent and heavy until the 14th, and showery weather continued in the northern counties during the remainder of the decade. A storm of considerable violence past southeastward over California from the 20th to 22d. There were no cold waves and no frost warnings which is unusual for the month of February.

The official in charge of the Weather Bureau office at San Diego, Cal., reports as follows regarding the storm of the the 20th-21st:

The benefits derived from warnings issued in connection with this storm were marked. The fishing fleets were on the point of departure for the banks, but the flags caused them to remain. Numerous excursion parties had chartered sloops and other craft and were ready to sail on cruises lasting over the approaching holiday, and they too remained in port. Extra moorings were placed by many of the craft at anchor in the bay, and only those thus safeguarded escaped being thrown on the beach. The wind was so severe that signals and halyards were carried away at the display stations, and the Spreckels Brothers Commercial Companies' bunkers were carried away after twelve hours strain.

—*Alexander G. McAdie, Professor of Meteorology.*

PORTLAND, OREG., FORECAST DISTRICT.†
[Oregon, Washington, and Idaho.]

The month was about as stormy as usual altho no noteworthy marine casualties occurred. The principal storm period was from the 12th to 20th, and during this period gales of 60 to 70 miles an hour were of frequent occurrence along the coast, and the winds in the Puget Sound country were at times as high as 40 or more miles an hour. Another stormy period occurred later in the month. Warnings of all gales were issued in time to be of benefit to marine interests on the north Pacific coast. On the morning of the 8th a cold wave threatened to overspread the eastern portion of the district and warnings for the expected change were issued. The appearance in the afternoon of a low-pressure area off the Washington coast prevented a sinking of temperature to a point to justify the warnings and they were accordingly canceled in the evening. Altho rivers were nearly all at stages above the normal no floods occurred nor were there any damaging washouts.—*E. A. Beals, District Forecaster.*

## RIVERS AND FLOODS.

THE FLOODS OF JANUARY AND FEBRUARY, 1909, IN THE SACRAMENTO VALLEY OF CALIFORNIA.

In the State of California the month of January, 1909, was characterized by heavy and almost continuous precipitation, the total amount ranging from 7 to 10 inches in the great valleys to much greater amounts at the higher elevations. At Kennett, near the mouth of the Pitt River, the precipitation for the month reached the astonishing total of 54.08 inches, probably the greatest precipitation ever recorded in a single month in the entire United States. This was followed by 24.30 inches during February. At Colgate, on the Yuba River, the total amount for the month was 29.10 inches, followed by 11.61 inches in February. There was also a considerable quantity of snow over the Sierras. The result, of course, was a great and very destructive flood. There was a moderate flood during the first decade of January, but the great flood did not begin until the 14th, when a rapid rise set in over the entire Sacramento River. There was an intermission during the last week of the month, followed by more heavy rains and another flood during the first week of February, and the last of the flood waters were just passing into Suisun Bay at the end of the month.

The flood did not differ materially in character from the one of March, 1907, except that the latter one was the more destructive of the two, and the losses and damage were such as usually result from great floods. At Red Bluff and Sacramento the crest stages of 30.5 feet on February 3, and of 29.6 feet on January 17, respectively, were the highest of record, while the crest stage of 23.9 feet on January 16 in the Yuba River at Marysville was 0.6 foot above the previous high-water record of March 19, 1907.

About 150,000 acres of land were overflowed, but, as the flood occurred during the winter season, the crop loss was reduced to a minimum. Efforts were made to secure reliable estimates of the losses and damage, and from these it appears that the amounts were approximately as follows:

| | |
|---|---|
| Property exclusive of crops | $1,715,000 |
| Crops | 611,000 |
| Erosion of farm lands | 76,000 |
| Suspension of business | 100,000 |
| Total | $2,502,000 |

The value of property saved thru the warnings of the Weather Bureau was about $300,000, comprising practically everything that could be moved.

The warnings issued by the Weather Bureau in connection with this flood were timely and accurate, and many testimonials relative to their high character and value have been received. They were instrumental in saving many lives as well as a large amount of property, and have demonstrated the fact that the River and Flood Service is an important adjunct to the further development of the great valley of the State of California.

GENERAL REMARKS.

High temperatures over the Ohio Valley watershed on February 22 and 23, combined with heavy rains on the latter date, resulted in a general, tho not severe, flood in the Ohio River and its western tributaries. It was most marked from Cincinnati, Ohio, westward, and at the end of the month the crest had just past Evansville, Ind., with a stage of 42.9 feet, 7.9 feet above the flood stage. The flood stage of 40 feet at Paducah, Ky., was exceeded by 1 foot at the same time.

At Cincinnati the crest stage was 54.6 feet, 4.6 feet above the flood stage, and at Louisville, Ky., 33 feet, 5 feet above the flood stage.

The interior rivers of the States of Ohio, Indiana, and Illinois were also in moderate flood, but no serious damage was done. Warnings were issued whenever necessary, and they were unusually effective in the State of Ohio. The total losses north of the Ohio River were probably not over $25,000, while the value of property saved thru the warnings of the Weather Bureau was at least ten times as much.

In the State of Kentucky, however, conditions were much more serious. The floods extended over the entire State, and all streams were out of their banks. At Louisville 5 inches of rain fell in twenty-four hours, and the property losses amounted to at least $300,000. In the interior of the State every industry suffered, and thousands of residents in the bottoms and lowlands were made homeless for some time. It is estimated that the total losses in the State of Kentucky amounted to several millions of dollars, the heaviest of which fell upon the agricultural and lumber interests.

Heavy rains with high temperatures on the 19th caused a severe freshet in the Hudson River below the mouth of the Mohawk River, and stages from 6 to 8.5 feet above the flood stages were experienced at Troy and Albany, N. Y., on the 21st. The abnormally high stage of 22.5 feet at Troy was in part caused by back water from the ice gorge, $2\frac{1}{4}$ miles below Albany. Warnings for the freshet were issued on the morning of the 20th, and little or no avoidable damage was reported. The total losses were about $225,000, of which $25,000 was due to enforced suspension of business. There was no damage to crops or farm lands, and the value of property saved by the warnings was about $100,000.

There was only a moderate freshet in the upper Susquehanna and upper Delaware rivers, and owing to timely warnings the resulting damage was inconsequential.

Moderate floods also occurred in the south during the second decade of the month, and the warnings therefor were of especial value to the cattle interests. In the Ocmulgee and Altamaha rivers the tide was a distinct benefit as it permitted the resumption of navigation after a suspension of about three months. In the southern portion of the State of Mississippi there were losses amounting to about $12,000, divided as follows:

| | |
|---|---|
| Property, exclusive of crops | $2,000 |
| Crops | 4,000 |
| Erosion of farm lands | 1,000 |
| Suspension of business | 5,000 |
| Total | $12,000 |

The value of property saved thru the warnings was $10,000.

The lower Missouri and upper Mississippi rivers were at moderate stages thruout the month, while the annual rise in the lower Mississippi River set in at New Madrid, Mo., on the 9th, reaching the flood stage of 34 feet on the 27th.

ICE.

The Missouri River opened at Omaha, Nebr., on the 27th, but remained closed above. Below Omaha it was opened during the greater portion of the month, and no ice of consequence was observed below the mouth of the Osage River. There was but little change in the Mississippi River, the ice continuing solid as a rule above Davenport, Iowa. No ice was observed below New Madrid, Mo.

There was some increase in the thickness of the ice in the upper Missouri River, with a maximum of 32 inches at Bismarck, N. Dak., an increase of 8 inches during the month. There was but little change in the upper Mississippi River, while in northern New England there was a little more ice than during January, 1909.

The highest and lowest water, mean stage, and monthly range at 198 river stations are given in Table IV. Hydrographs for typical points on seven principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*H. C. Frankenfield, Professor of Meteorology.*

# SPECIAL ARTICLES, NOTES, AND EXTRACTS.

## NOTES FROM THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Librarian.

### THE ISOTHERMAL LAYER OVER EQUATORIAL AFRICA.

The most interesting piece of news that has come to us from meteorological circles abroad since the last installment of these notes was written is the announcement that the recent German aerological expedition to East Africa (See MONTHLY WEATHER REVIEW, December 1908, p. 422) found the isothermal or relatively warm stratum of the high atmosphere over Victoria Nyanza. This and other results of the expedition are published in the January, 1909, number of the Quarterly Journal of the Royal Meteorological Society in a communication from Doctor Assmann, director of the Royal Prussian Aeronautical Observatory at Lindenberg, dated January 31, 1909.

The isothermal layer was reached by two ascents of sounding-balloons, at altitudes of 65,000 and 56,000 feet (19,800 and 17,000 meters). It will be remembered that the *Otaria* expedition, sent out by Messrs. Rotch and Teisserenc de Bort, failed to reach this layer over the equatorial regions of the Atlantic, tho some of their balloons rose to nearly 50,000 feet; but Rotch and others have confidently predicted that it would be found in equatorial regions as soon as balloons could be raised to a sufficient altitude. We may now safely conclude that this phenomenon is common to all latitudes, having its greatest elevation in the neighborhood of the equator and its least over the poles.

Especially remarkable, says Doctor Assmann, is the great average decrease of temperature with altitude found over Lake Victoria; the lowest temperature encountered at 65,000 feet (19,800 meters), was −119°F. (−84°C.), with a temperature at the ground (3,800 feet, or 1,150 meters, above sea level) of 79°F. (26°C.). The variability of the temperature at high levels is enormous in equatorial, as well as in higher latitudes. Two ascents gave readings at 56,000 feet (17,000 meters) of −105°F. (−76°C.) and −62°F. (−52°C.), respectively.

In addition to the ascents of sounding-balloons a number of small pilot-balloons were sent up to great altitudes to explore the direction and velocity of the upper air currents, and these showed the presence of an uppermost current of air blowing nearly from due *west*, and flowing above the regular easterly current of the equatorial region. A similar discovery was made some time ago at Cairo, Egypt, by B. F. E. Keeling, as recorded in these notes last June.

The ascents over Lake Victoria were made from a low-powered launch, and would have yielded better results had a faster boat been available. It is stated that with a vessel having a speed of some 12 miles an hour this lake is the best place in the world for sounding-balloon ascents, because the winds are generally feeble enough to permit the recovery of all the balloons sent up.

### THE METEOROLOGY OF ABYSSINIA AND THE NILE FLOOD.[1]

Another African expedition of much interest was that sent to Addis Abbaba, the capital of Abyssinia, in May, 1907, by the meteorological service of Egypt, to study the meteorological conditions controlling the Nile flood. As pointed out in these notes some years ago,[2] the Nile flood is a faithful index to the rainfall of Abyssinia, since the Blue Nile, when in flood, holds back the water of the White Nile, so that the contribution of the latter to the flood is negligible. Thus the meteorology of Abyssinia, the country in which the Blue Nile takes its rise, is a matter of great interest to the people of Egypt.

The chief rainfall was found to be associated with thunderstorms. Nevertheless, tho accounts from all parts of Abyssinia agree that the intensity of electrical phenomena was much greater in 1907 than it had been for years, a condition favoring heavy rainfall, the latter was actually much lighter than usual—as shown by the very low flood of that year. This contradiction is explained by the statement that the rain-bearing winds were much weaker than usual. While the atmospheric circulation in this part of the world calls for much further investigation, the author of the memoir under discussion states confidently that the moisture precipitated over Abyssinia comes all the way across the African Continent from the South Atlantic Ocean. The writer adds:

> This theory bears on only one factor of the rainfall, the supply of moisture. The velocity of the current would still be in great part determined by the isobaric gradients of the great monsoon depression, and finally the convectional ascensional movement would probably require separate discussion.

A much more elaborate report on the results of this expedition is in preparation.

### THE WEATHER SERVICE OF THE FRANKFORT AERONAUTICAL EXPOSITION.

Dr. F. Linke announces in Illustrierte aeronautische Mitteilungen that the Geophysical Institute of the Physical Society of Frankfort-on-the-Main has undertaken to organize a special weather service for the Frankfort Aeronautical Exposition (July–October, 1909). Telegrams from the whole of Europe will be received twice a day and two weather maps drawn. Observations from the higher strata of the atmosphere will also be obtained. Of course the conditions over Frankfort will be of first importance. An aerological station will be established in Frankfort, where once or twice a day soundings of the lower layers of the atmosphere will be made by means of kites or captive balloons with self-registering instruments.

[1] Craig, J. I. A meteorological expedition to Addis Abbaba, in 1907. Alexandria, 1909. (Reprinted from the "Cairo scientific journal," No. 27, 1908.)

[2] Monthly Weather Review, May, 1906, 34:228.

Finally, in the neighborhood of Frankfort, to a distance of perhaps 100 kilometers, stations will be located, whence warnings will be sent to the weather service station at this place of the approach of thunderstorms and squalls and, after they have past, reports by telegraph of the time and direction of path. By means of such despatches the time when such storms will reach Frankfort can be calculated with tolerable accuracy. Signal stations will be located at conspicuous points, from which storm warnings can be sent to balloons and other air craft by means of optical signals; possibly also by wireless telegraphy.

Doctor Linke does not exaggerate the importance of this project when he says:

The wider object of this organization is, of course, the acquisition of knowledge and experience *for the coming era of aerial navigation;* the consummation of which, on account of the uncertainty of atmospheric conditions, is impossible without the previous improvement and extension of the weather service. That such an undertaking will at the same time increase our knowledge of atmospheric processes and thereby improve the accuracy of the forecasts, is evident. ***Aeronautics and meteorology support each other***, neither can dispense with the other.

It is perhaps not too much to say that the execution of this project will mark the beginning of a new era in practical meteorology—an era in which, ultimately, all the weather services of the world will be called upon to extend the benefits of their forecasts and warnings to the navigators of the air. The development of aeronautics means *the enhancement of the importance of meteorology among the sciences and in the domain of practical affairs.* The rapid progress that this art has made within the last few years must, therefore, be a source of gratification and encouragement to all meteorologists.

THE ARGENTINE METEOROLOGICAL STATION IN THE SOUTH ORKNEYS.

The corvette *Uruguay*, of the Argentine Navy, left Buenos Ayres on January 14 for the meteorological and magnetical station at the South Orkneys. The relief party sent out by the Argentine Meteorological Office consists of four members, under the command of Mr. A. Lindsay, of Edinburgh, who received his early meteorological training at the Ben Nevis Observatory, and who for the past year has been in charge of the new meteorological observatory established at Port Madryn, in the territory of Chubut [Argentina]. The observations at the South Orkneys this year are likely to prove of unusual interest and importance owing to the comparative proximity of the Charcot expedition, which is to winter in the vicinity of Alexander Land. On the return voyage of the *Uruguay* a stop is to be made at Moltke Haven, South Georgia, in order to make magnetic observations in the same spot as that previously occupied by the German International Expedition of 1882–83. This work is intrusted to Mr. W. R. Bruce, chief last year at the South Orkney station, who, along with the rest of the party, returns with the *Uruguay*. The data from South Georgia will be of great value in connection with the elaborate magnetic survey of the Argentine Republic and adjacent regions which has been in progress for some years.—*Scottish Geographical Magazine, March, 1909, p. 151.*

AN INVERTED RAINBOW.

On April 9, 1908, an inverted rainbow was seen from the Italian geodynamic observatory of Rocca de Papa, by Professor Agamennone, the director of the observatory, and a party of visitors. The morning was showery; and when the visitors reached the observatory, 2,500 feet above sea level, and looked dawn on the vast Campagna, they were astonished to see projected on the vineyards and trees beneath a perfect rainbow, with its convex side down and its middle point bearing northeast. Inverted rainbows are very rare even in mountainous regions. None of the visitors, who were French and Italian meteorologists, had ever seen one, nor had Professor Agamennone, altho he had been director of the observatory for eight years. The phenomenon, however, is not unknown. It was observed from the Eiffel Tower, in Paris, in April, 1891. In this case there was a double rainbow, extending above and below the horizon to form two nearly complete concentric circles.—*Scientific American, March 20, 1909, p. 219.*

## PRIZE OFFERED BY THE SCOTTISH METEOROLOGICAL SOCIETY.

The Scottish Meteorological Society offers, thru its council, a prize of £20 for the best essay on a meteorological subject. As an indication of the kind of essay the council are prepared to consider, the following subject may be mentioned:—

"A discussion of the extent to which the heat set free when water vapor is converted into the liquid state influences the temperature of the atmosphere, with special reference to the climatology of different parts of Scotland."

The council, however, wish it to be clearly understood that an essay on any subject will be equally eligible.

The following are the conditions on which the prize is offered:—

1. The competition shall be open to regular matriculated students of the four Scottish universities, including University College, Dundee, who have attended classes of mathematics and natural philosophy, or to graduates of the Scottish universities who at 1st January, 1910, shall be of not more than five years' standing.
2. The essays must be lodged with the secretary to the Scottish Meteorological Society, 122 George street, Edinburgh, on or before 31st March, 1910, with a statement of the candidate's qualifications to compete.
3. All essays must be legibly written, or typewritten, on one side of the paper only.
4. The council of the Society shall appoint a referee or referees to report on the essays, and the decision of the council as intimated by the secretary shall be final.
5. The council reserve the right to publish the successful essay in the Society's Journal. The other essays will be returned to the competitors.

R. T. OMOND,
E. M. WEDDERBURN,
*Joint Honorary Secretaries.*

## DR. SERENO BISHOP.

We regret to learn of the recent serious illness and death, January, 1909, of Dr. Sereno E. Bishop at Honolulu, H. I. For more than a year Doctor Bishop had been partially paralyzed, altho his general bodily health has been good. Almost the last of his intelligent activities were his observations of the skies at the end of 1908, when he noted the haze, Bishop's ring, and some sky-glows too brilliant for the average atmosphere.—*C. A.*

## SUMMARY OF ICE CONDITIONS OF THE GREAT LAKES.

By NORMAN B. CONGER, Marine Agent. Dated Detroit, Mich., March 2, 1909.

The reports from the regular and display stations of the U. S. Weather Bureau indicate that there is much less ice in all the lakes than was reported last season. In Lake Superior, the western end is covered with a field extending out about 20 miles; small fields are reported over the central and eastern portions. The ice in Whitefish Bay is solid. Solid ice is reported the entire length of St. Marys River. In Green Bay the ice averages from 10 to 22 inches and is solid. In Lake Michigan the fields are small and much broken up. There are not as many fields reported over the northern portion. At the Straits of Mackinac the ice is heavily windrowed in places, and where smooth is about 20 inches in thickness. In Lake Huron the fields are reported to the north and east of Thunder Bay Island. The ice is not heavy. No fields are reported over the southern portion. Lake St. Clair is reported covered with about 7 inches of ice, with probably some open

water. The Detroit River is open. In Lake Erie the ice fields cover the western and eastern portions, but these fields are not heavy or extensive. In Lake Ontario the ice fields have not been visible to any extent during the winter. Many harbors are reported open on all the lakes.

In comparison with the same period last season there is much less ice reported in all of the lakes. At the Straits of Mackinac the same conditions prevail as last season except that the ice fields are not as extensive in Lake Michigan.

## STUDIES ON THE VORTICES IN THE ATMOSPHERE OF THE EARTH.

By Prof. FRANK H. BIGELOW. Dated Washington, D. C., March 16, 1908.

### VI.—THE ASYMMETRIC LAND CYCLONE AND ITS SYSTEM OF VORTEX LINES. THE CONCAVE DUMB-BELL-SHAPED VORTEX.

#### THE METEOROLOGICAL DATA.

It is necessary to construct a typical composite vortex, reduced to circular isobars, for the discussion of the system of vortex lines which will produce the circulation observed in the land cyclones of the United States. For this purpose the data for the nine typical cyclones in the accompanying list have been brought together, and their common properties united in the following manner. The cyclones are those of March 16, 1876; March 27, 1880; April 18, 1880; January 12, 1890; December 3, 1891; November 17, 1892; April 20, 1893; January 25, 1895; November 22, 1898. These were selected as having the center located near the middle Ohio Valley, and being approximately of the same dimensions. This insures the temperature distribution having a simple type, the warm air flowing from the south and the cold air from the north, while the normal isotherms are nearly parallel to the east and west lines. At the same time the isobars are nearly circular or broadly elliptical, and the wind vectors are but little distorted by local conditions, so that the composite cyclone will be a fair example for study.

*The radii* $\varpi$.—The construction of the isobar system is chiefly concerned with determining the proper spacing of the successive isobaric circles, and the treatment is illustrated by the cyclone of March 16, 1876. The diameter of every isobar was measured in millimeters in the northwest to southeast and the southwest to northeast directions, and the sum divided by four is the mean radius $\varpi$. The successive differences $\Delta\varpi$ for every tenth of an inch were found, and the mean taken for the nine selected cyclones.

TABLE 75.—*The mean radii $\varpi$ and differences $\Delta\varpi$ for the cyclone, March 16, 1876.*

| Isobars. | Measured diameters. | | | Mean radii. | |
|---|---|---|---|---|---|
| | NW-SE. | SW-NE. | Sum. | $\varpi$ | $\Delta\varpi$ |
| *Inches.* 30.00 | 300 | 220 | 520 | 130 | 17 |
| 29.90 | 267 | 186 | 453 | 113 | 15 |
| 29.80 | 240 | 150 | 390 | 98 | 11 |
| 29.70 | 218 | 130 | 348 | 87 | 14 |
| 29.60 | 190 | 102 | 292 | 73 | 12 |
| 29.50 | 158 | 85 | 243 | 61 | 11 |
| 29.40 | 128 | 71 | 199 | 50 | 13 |
| 29.30 | 90 | 57 | 147 | 37 | 10 |
| 29.20 | 62 | 45 | 107 | 27 | 7 |
| 29.10 | 48 | 33 | 81 | 20 | 11 |
| 29.00 | 22 | 15 | 37 | 9 | |

Table 75 contains the measured diameters in two directions at right angles to each other, toward the northwest and northeast respectively, the sum, the mean radius $\varpi$, and the differences $\Delta\varpi$ for the cyclone, March 16, 1876. Table 76 contains the values of $\Delta\varpi$ for nine cyclones, similarly located and developed, the mean $\Delta\varpi$ and the adjusted $\Delta\varpi$ found by a graphical construction. Table 77 gives the adopted value of the radius for each tenth-inch of pressure, assuming $\varpi$ = 140.5 millimeters for the isobar 30.00 inches. These are reduced by interpolation for every 5 millimeters of pressure from 760 millimeters to 735 millimeters. Then are given the $\log \varpi$ and $\log \rho = \log \varpi_n - \log \varpi_{n+1}$, and finally $\varpi$ in meters, taking 1 millimeter on the Weather Bureau Map equivalent to 10,000 meters on the surface of the ground in the United States. It will be carefully observed that the values of $\log \rho$ instead of being constant, as in the tornado, hurricane, and in a part of the ocean cyclone, are progressive from 0.10791 to 0.43573, and this proves that the *land cyclone has departed seriously from the perfect dumb-bell vortex type*, which was found to be applicable to the other vortices in the atmosphere.

TABLE 76.—*The mean and adjusted $\Delta\varpi$ from the nine selected cyclones.*

| Isobars. | | Mar. 16, 1876. | Mar. 27, 1880. | Apr. 18, 1880. | Jan. 12, 1890. | Dec. 3, 1891. | Nov. 17, 1892. | Apr. 20, 1893. | Jan 25, 1895. | Nov. 22, 1898. | Mean $\Delta\varpi$ | Adjusted $\Delta\varpi$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Mm.* 762.0 | *Inches.* 30.00 | 17 | 20 | 21 | 12 | 18 | 20 | 22 | 16 | 14 | 17.8 | 17.0 |
| 759.5 | 29.90 | 15 | 15 | 13 | 11 | 16 | 18 | 12 | 18 | 11 | 14.3 | 15.7 |
| 756.9 | 29.80 | 11 | 13 | 15 | 15 | 17 | 15 | 19 | 17 | 14 | 15.1 | 14.5 |
| 754.4 | 29.70 | 14 | 14 | 15 | 13 | 11 | 8 | 15 | 19 | 14 | 13.7 | 13.4 |
| 751.8 | 29.60 | 12 | 10 | 15* | 12 | 11 | 9 | 10 | 12 | 19 | 12.2 | 12.4 |
| 749.3 | 29.50 | 11 | 14 | 12 | 11 | 11 | 11 | 8 | 9 | 10 | 10.8 | 11.4 |
| 746.8 | 29.40 | 13 | 8 | 11 | 8 | 9 | 9 | 9 | 11 | ...... | 9.6 | 10.6 |
| 744.2 | 29.30 | 10 | 9 | 8 | ...... | 15 | 9 | 6 | 11 | ...... | 9.7 | 10.0 |
| 741.7 | 29.20 | 7 | 10 | 9 | ...... | 15 | 10 | 10 | ...... | ...... | 10.2 | 10.0 |
| 739.1 | 29.10 | 11 | 11 | 13 | ...... | ...... | ...... | 6 | ...... | ...... | 10.3 | 10.1 |
| 736.6 | 29.00 | | | | | | | | | | | |

TABLE 77.—*Computation of $\log \rho$ for the land cyclones and the distance of the isobars from the center.*

| $B$ | $\varpi$ | Isobars. | | $\varpi$ | $\log \varpi$ | $\log \rho$ | $\varpi$ |
|---|---|---|---|---|---|---|---|
| *Inches.* | *Mm.* | *Inches.* | *Mm.* | *Mm.* | | | *Meters.* |
| 30.00 | 140.5 | | | | | | |
| 29.90 | 123.5 | 29.92 | 760 | 125.0 | 2.09691 | | 1250000 |
| 29.80 | 107.8 | | | | | 0.10791 | |
| 29.70 | 93.3 | 29.72 | 755 | 97.5 | 1.98900 | | 975000 |
| 29.60 | 79.9 | | | | | 0.12390 | |
| 29.50 | 67.5 | 29.53 | 750 | 73.3 | 1.86510 | | 733000 |
| 29.40 | 56.1 | | | | | 0.15924 | |
| 29.30 | 45.5 | 29.33 | 745 | 50.8 | 1.70586 | | 508000 |
| 29.20 | 35.5 | | | | | 0.22874 | |
| 29.10 | 25.5 | 29.13 | 740 | 30.0 | 1.47712 | | 300000 |
| 29.00 | 15.4 | | | | | 0.43573 | |
| 28.90 | 5.0 | 28.94 | 735 | 11.0 | 1.04139 | | 110000 |

*The wind velocities, angles, and the temperatures.*—The discussion of the wind velocities, the angle $i$ that the wind vector makes with the tangent to the isobars, and the temperatures, has been carried on in the same way for these three quantities. From the center twelve radii were drawn across the isobars 30.00 to 29.00 inches, the radii being located as follows:

| | | | |
|---|---|---|---|
| 1. S. | 4. E. | 7. N. | 10. W. |
| 2. S. 30° E. | 5. E. 30° N. | 8. N. 30° W. | 11. W. 30° S. |
| 3. S. 60° E. | 6. E. 60° N. | 9. N. 60° W. | 12. W. 60° S. |

At the intersection of these radii with the isobars the wind velocity was scaled from the data on the manuscript chart and collected in Table 78, the angle $i$ in Table 79, and the temperature $t$ in Table 80. Examples of these data are given for the cyclone of March 16, 1876. The next step was to collect the same elements together at each point for the nine cyclones, and take out the mean values.

TABLE 78. – *The wind velocities in miles per hour for March 16, 1876.*

| | 30.00 | 29.90 | 29.80 | 29.70 | 29.60 | 29.50 | 29.40 | 29.30 | 29.20 | 29.10 | 29.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S. | 10 | 10 | 12 | 14 | 28 | 54 | 42 | 20 | 14 | ...... | ...... |
| S. 30° E. | 12 | 10 | 18 | 20 | 20 | 16 | 20 | 16 | 18 | ...... | ...... |
| S. 60° E. | 10 | 26 | 40 | 40 | 20 | 12 | 14 | 24 | 16 | ...... | ...... |
| E. | 12 | 20 | 24 | 24 | 16 | 10 | 14 | 8 | 10 | ...... | ...... |
| E. 30° N | 20 | 24 | 26 | 18 | 18 | 20 | 22 | 10 | 12 | ...... | ...... |
| E. 60° N | ...... | ...... | 18 | 24 | 28 | 20 | 26 | 12 | 12 | ...... | ...... |
| N. | ...... | ...... | ...... | 24 | 24 | 24 | 24 | 20 | 14 | ...... | ...... |
| N. 30° W. | 18 | 30 | 32 | 36 | 30 | 24 | 24 | 18 | 20 | ...... | ...... |
| N. 60° W. | 28 | 30 | 36 | 36 | 30 | 24 | 24 | 16 | 16 | ...... | ...... |
| W. | 24 | 28 | 28 | 26 | 24 | 21 | 19 | 14 | 16 | ...... | ...... |
| W. 30° S. | 8 | 12 | 20 | 24 | 28 | 28 | 26 | 22 | 19 | ...... | ...... |
| W. 60° S. | 6 | 14 | 20 | 24 | 36 | 34 | 24 | 20 | 20 | ...... | ...... |

TABLE 79. — *The angle $-i$ for March 16, 1876.*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° |
| S. | 40 | 35 | 40 | 45 | 50 | 50 | 55 | 55 | 55 | 56 | 60 |
| S. 30° E. | 42 | 48 | 45 | 50 | 40 | 40 | 45 | 30 | 30 | 25 | 20 |
| S. 60° E. | 30 | 30 | 30 | 25 | 25 | 20 | 40 | 45 | 35 | 20 | 25 |
| E. | 25 | 25 | 30 | 30 | 30 | 35 | 30 | 30 | 25 | 25 | 20 |
| E. 30° N | 90 | 90 | 90 | 90 | 75 | 60 | 60 | 65 | 55 | 55 | 50 |
| E. 60° N. | ...... | ...... | ...... | 40 | 45 | 45 | 40 | 35 | 45 | 45 | 40 |
| N. | ...... | ...... | ...... | 40 | 40 | 45 | 45 | 40 | 40 | 35 | 35 |
| N. 30° W. | 45 | 50 | 55 | 50 | 50 | 55 | 55 | 50 | 45 | 35 | 30 |
| N. 60° W. | 65 | 40 | 35 | 35 | 30 | 25 | 25 | 25 | 30 | 30 | 35 |
| W. | 65 | 60 | 60 | 50 | 45 | 40 | 40 | 35 | 30 | 40 | 45 |
| W. 30° S. | 55 | 40 | 35 | 30 | 25 | 15 | 30 | 20 | 25 | 30 | 45 |
| W. 60° S. | 45 | 45 | 45 | 45 | 50 | 55 | 55 | 50 | 50 | 45 | 45 |

TABLE 80. – *The temperatures for March 16, 1876, in degrees Fahrenheit.*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | |
| S. | 78 | 74 | 59 | 60 | 47 | 40 | 42 | 40 | 40 | 38 | ...... |
| S. 30° E. | 74 | 70 | 70 | 67 | 67 | 56 | 51 | 52 | 52 | 48 | ...... |
| S. 60° E. | 64 | 64 | 64 | 62 | 63 | 52 | 44 | 50 | 52 | 51 | ...... |
| E. | 40 | 40 | 38 | 34 | 38 | 36 | 35 | 38 | 38 | 40 | ...... |
| E. 30° N. | 18 | 15 | 10 | 12 | 16 | 18 | 24 | 32 | 33 | 34 | ...... |
| E. 60° N | 0 | 3 | 9 | 11 | 14 | 16 | 20 | 19 | 30 | 30 | ...... |
| N. | − 2 | 5 | 10 | 12 | 14 | 16 | 18 | 19 | 20 | 24 | ...... |
| N. 30° W. | 10 | 12 | 12 | 14 | 16 | 19 | 20 | 20 | 27 | 26 | ...... |
| N. 60° W. | 9 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | ...... |
| W. | 20 | 16 | 20 | 19 | 21 | 23 | 24 | 26 | 26 | 30 | ...... |
| W. 30° S. | 42 | 33 | 30 | 27 | 32 | 30 | 29 | 30 | 30 | 32 | ...... |
| W. 60° S | 53 | 47 | 44 | 40 | 40 | 36 | 24 | 36 | 35 | 36 | ...... |

The negative sign for the angle $i$ means that the vectors are directed inward relative to the isobars, or in other words the radial velocity has the negative sign, $-u$.

In Table 81 the data for the nine selected cyclones are given for a mean or composite cyclone. The data were extracted from the original charts, as in Tables 78, 79, and 80, and the means taken at each point of intersection of the radii and the isobars. The variations of the elements can be readily studied by inspection. In Table 81, I, the mean wind velocity for each isobar is taken, this giving data for a uniform or perfect cyclone from which all the irregularities of the circulation have been eliminated. These have been transformed into velocities in meters per second by the factor 0.447. In Table 81, II, the interior angle $-i$ is seen to vary considerably from point to point, but the mean values for each isobar are taken, and they prove to be nearly constant, about 44°, except on the inner isobar, where it diminishes to 40°. If the cyclone were a true dumb-bell vortex, it would be easy to construct the entire system from these data, assuming the height of the plane to be taken as the asymptote. It will not, however, be profitable to proceed on this supposition. With the values of $q$ and $-i$ the corresponding velocities $-u$ (radial) and $+v$ (tangential) have been computed. Finally, these values were interpolated for the corresponding isobars, 760, 755, 750, 745, 740, 735 millimeters, and the discussion will be generally transformed into the metric system. In Table 81, III, the temperatures in degrees Fahrenheit are collected together, and they range from 11.3° F. to 70.7° F. In all cases of the velocity, angle, and temperature, the points corresponding with the first collection of the data were plotted and average curves were drawn thru the points. The values which appear in Table 81 are thus somewhat smoothed, but no essential differences occur. The slope and the curvature of these lines form a subject of much interest and they are very instructive.

TABLE 81. — *The mean wind velocities, angle i, and temperatures derived from nine typical cyclones central near the Ohio Valley.*

I. ADJUSTED WIND VELOCITIES, IN MILES PER HOUR.

| $B$ (inches). $B$ (mm.) | 30.00 762.0 | 29.90 759.5 | 29.80 756.9 | 29.70 754.4 | 29.60 751.8 | 29.50 749.3 | 29.40 746.8 | 29.30 744.2 | 29.20 741.7 | 29.10 739.1 | 29.00 736.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S. | 14.2 | 14.4 | 14.9 | 16.7 | 20.0 | 23.3 | 25.6 | 27.0 | 28.0 | 28.2 | 28.0 |
| S. 30° E. | 12.3 | 13.8 | 15.7 | 17.5 | 19.2 | 20.8 | 22.4 | 23.4 | 24.0 | 24.2 | 24.4 |
| S. 60° E. | 14.0 | 15.2 | 16.4 | 17.7 | 18.7 | 19.7 | 20.6 | 21.3 | 22.0 | 22.4 | 22.6 |
| E. | 14.0 | 15.8 | 17.0 | 17.0 | 16.4 | 16.0 | 15.3 | 15.2 | 15.7 | 16.8 | 18.0 |
| E. 30° N. | 16.8 | 17.8 | 18.0 | 18.3 | 18.8 | 19.2 | 19.0 | 18.1 | 17.6 | 17.7 | 18.2 |
| E. 60° N. | 17.0 | 17.6 | 17.3 | 17.1 | 17.2 | 17.5 | 17.7 | 17.8 | 17.6 | 17.4 | 17.0 |
| N. | 14.0 | 14.6 | 15.3 | 16.5 | 18.4 | 21.0 | 23.8 | 25.4 | 25.4 | 23.7 | 22.2 |
| N. 30° W. | 13.7 | 15.0 | 17.3 | 20.0 | 22.6 | 24.7 | 25.9 | 25.8 | 24.4 | 22.5 | 22.0 |
| N. 60° W. | 16.4 | 18.6 | 21.0 | 23.2 | 24.4 | 24.7 | 24.8 | 24.4 | 23.6 | 23.1 | 23.0 |
| W. | 17.0 | 20.8 | 23.2 | 24.4 | 25.3 | 25.8 | 26.0 | 25.6 | 25.2 | 25.4 | 25.7 |
| W. 30° S. | 14.0 | 15.6 | 17.4 | 19.1 | 20.7 | 22.5 | 23.7 | 24.4 | 24.8 | 24.8 | 25.0 |
| W. 60° S. | 12.5 | 15.6 | 19.2 | 21.5 | 23.2 | 24.4 | 25.0 | 25.0 | 25.0 | 24.7 | 24.3 |
| Means | 14.7 | 16.2 | 17.7 | 18.8 | 20.4 | 21.6 | 22.5 | 22.8 | 22.8 | 22.6 | 22.5 |
| | | | Velocities in meters per second. | | | | | | | | |
| $q$ | 6.6 | 7.2 | 7.9 | 8.4 | 9.1 | 9.6 | 10.1 | 10.2 | 10.2 | 10.1 | 10.0 |

II. $-i$ = ANGLE OF THE WIND WITH THE ISOBAR.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | |
| S. | 47.8 | 46.4 | 45.3 | 44.2 | 43.7 | 43.0 | 42.6 | 43.3 | 44.0 | 44.8 | 45.8 | |
| S. 30° E. | 44.0 | 45.0 | 45.8 | 46.0 | 46.0 | 45.7 | 45.2 | 44.0 | 42.6 | 40.5 | 38.5 | |
| S. 60° E. | 34.6 | 37.2 | 39.2 | 41.3 | 43.5 | 44.6 | 44.7 | 44.8 | 41.5 | 38.0 | 35.3 | |
| E. | 39.0 | 40.5 | 41.6 | 42.5 | 43.0 | 42.7 | 41.8 | 40.7 | 39.6 | 38.4 | 37.5 | |
| E. 30° N. | 40.0 | 42.0 | 44.0 | 45.4 | 46.2 | 46.2 | 46.0 | 45.8 | 45.5 | 45.0 | 45.0 | |
| E. 60° N. | 27.5 | 29.0 | 32.4 | 33.8 | 39.0 | 42.0 | 43.8 | 44.0 | 43.6 | 42.0 | 40.4 | |
| N. | 53.3 | 53.8 | 54.0 | 54.0 | 54.0 | 54.0 | 53.7 | 52.8 | 51.4 | 49.8 | 48.0 | |
| N. 30° W. | 56.0 | 54.6 | 53.0 | 51.2 | 49.5 | 47.8 | 46.0 | 44.2 | 42.8 | 41.5 | 40.3 | |
| N. 60° W. | 50.2 | 48.7 | 47.4 | 45.5 | 44.0 | 42.6 | 41.5 | 40.2 | 39.3 | 38.3 | 38.0 | |
| W. | 44.4 | 43.3 | 41.6 | 40.0 | 38.5 | 37.2 | 35.8 | 34.7 | 33.8 | 32.8 | 32.0 | |
| W. 30° S. | 40.0 | 38.4 | 37.3 | 36.2 | 35.0 | 34.4 | 34.2 | 34.0 | 34.0 | 34.0 | 34.0 | |
| W. 60° S. | 50.5 | 51.2 | 51.4 | 51.6 | 51.8 | 52.0 | 51.0 | 49.2 | 46.4 | 43.8 | 40.5 | |
| Mean $-i$. | 43.9 | 44.2 | 44.4 | 44.5 | 44.5 | 44.4 | 43.9 | 43.1 | 42.0 | 40.7 | 39.6 | |
| | | The component velocities in meters per second. | | | | | | | | | | |
| $-u$ | −4.5 | −4.9 | −5.4 | −5.7 | −6.2 | −6.5 | −6.9 | −7.0 | −7.0 | −6.9 | −6.8 | |
| $+v$ | 4.8 | 5.3 | 5.8 | 6.1 | 6.7 | 7.0 | 7.4 | 7.5 | 7.5 | 7.4 | 7.3 | |
| $B$ (mm.) | ...... | 760.0 | ...... | 755.0 | ...... | 750.0 | ...... | 745.0 | ...... | 740.0 | ...... | 735.0 |
| $-u$ | ...... | −4.9 | ...... | −5.6 | ...... | −6.4 | ...... | −7.0 | ...... | −6.9 | ...... | −6.8 |
| $+v$ | ...... | 5.2 | ...... | 6.0 | ...... | 6.9 | ...... | 7.5 | ...... | 7.4 | ...... | 7.3 |

III. TEMPERATURES, IN DEGREES FAHRENHEIT.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° |
| S. | 67.2 | 63.0 | 59.5 | 56.6 | 54.6 | 52.9 | 51.2 | 49.8 | 48.7 | 47.7 | 47.0 |
| S. 30° E. | 70.7 | 68.3 | 66.2 | 64.0 | 62.0 | 60.0 | 58.0 | 56.3 | 54.7 | 53.2 | 52.0 |
| S. 60° E | 65.2 | 63.5 | 62.0 | 60.6 | 59.3 | 58.0 | 56.8 | 55.7 | 54.6 | 53.8 | 53.0 |
| E. | 48.7 | 47.6 | 47.4 | 48.0 | 49.8 | 50.4 | 50.3 | 49.9 | 49.3 | 48.7 | 48.0 |
| E. 30° N. | 30.0 | 30.9 | 32.5 | 34.6 | 37.0 | 38.9 | 40.4 | 41.6 | 43.0 | 44.0 | 45.0 |
| E. 60° N. | 19.0 | 21.9 | 25.5 | 28.4 | 31.4 | 34.1 | 36.8 | 38.8 | 41.0 | 43.2 | 45.0 |
| N. | 11.3 | 14.6 | 17.8 | 20.7 | 23.4 | 26.2 | 29.4 | 32.4 | 35.2 | 38.0 | 41.0 |
| N. 30° W | 12.2 | 14.4 | 16.7 | 19.4 | 22.0 | 24.9 | 28.0 | 31.0 | 34.0 | 37.7 | 41.0 |
| N. 60° W. | 15.6 | 17.4 | 19.3 | 20.9 | 22.6 | 24.3 | 26.2 | 28.6 | 31.9 | 35.7 | 40.0 |
| W. | 19.5 | 20.5 | 21.9 | 23.5 | 25.3 | 27.7 | 30.2 | 33.0 | 36.2 | 39.6 | 44.0 |
| W. 30° S. | 31.2 | 31.4 | 31.8 | 32.2 | 33.1 | 34.1 | 35.4 | 35.9 | 39.0 | 41.4 | 44.3 |
| W. 60° S. | 46.9 | 46.0 | 45.0 | 44.3 | 43.8 | 43.6 | 43.8 | 44.0 | 44.7 | 45.4 | 46.4 |

We next interpolated all the values of $q$, $-i$, and $t$ in the English system to the corresponding values in the metric system, and plotted them on diagrams constructed from the isobar distances given in Table 77.

| B. | $\varpi$ |
|---|---|
| *Mm.* | *Meters* |
| 760 | 1250000 |
| 755 | 975000 |
| 750 | 733000 |
| 745 | 508000 |
| 740 | 300000 |
| 735 | 110000 |

These diagrams are not reproduced. Returning to the original charts of the nine selected cyclones, the mean temperatures in a north-and-south line thru the central region

were carefully computed, giving the adopted mean values of the temperature in latitude for this region, the normal isobars running nearly east and west in this part of the United States.

TABLE 82.—*Mean temperatures thru the center from north to south.*

| B. | | °C. |
|---|---|---|
| *Mm.* | | ° |
| 760 | N. | − 9.2 |
| 755 | N. | − 6.5 |
| 750 | N. | − 3.8 |
| 745 | N. | − 1.2 |
| 740 | N. | + 1.2 |
| 735 | N. | 3.5 |
| 732.5 | | 5.0 |
| 735 | S. | 6.4 |
| 740 | S. | 8.7 |
| 745 | S. | 11.0 |
| 750 | S. | 13.6 |
| 755 | S. | 16.3 |
| 760 | S. | 19.1 |

These temperatures were carefully compiled from point to point in latitude, and embrace the set of temperatures in longitude covered by the cyclone, so that they become the normals for this group of cyclones from which the variations are to be computed. The temperatures in Table 81, III, were turned into centigrade degrees, and then they were interpolated from the system of isobars in inches to the adopted system of isobars in millimeters. From these, on the respective parallels, the normal temperature is to be subtracted to obtain the temperature residuals or variations which distinguish a cyclone from the temperatures belonging to the same area, if it were undisturbed by any *local* circulations.

TABLE 83.—*The variation of temperature (°C), wind velocity (m/sec.), and the angle −i in a mean cyclone of the United States.*

| Radius. | S. | S. 30° E. | S. 60° E. | E. | E. 30° N. | E. 60° N. | N. | N. 30° W. | N. 60° W. | W. | W. 30° S. | W. 60° S. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **I. Δt. TEMPERATURE VARIATIONS, CENTIGRADE.** | | | | | | | | | | | |
| 760 | −1.3 | +1.3 | +2.9 | +2.1 | +1.7 | +2.2 | 0.0 | −1.1 | −3.2 | −6.4 | −7.1 | −5.6 |
| 755 | −1.5 | +1.7 | +2.8 | +2.1 | +1.8 | +2.3 | +0.1 | −1.2 | −3.0 | −5.5 | −6.1 | −4.6 |
| 750 | −1.1 | +1.9 | +2.9 | +2.8 | +1.7 | +2.1 | +0.1 | −1.0 | −2.8 | −4.3 | −4.7 | −3.3 |
| 745 | −0.5 | +1.4 | +2.9 | +2.8 | +1.7 | +1.8 | +0.7 | −0.4 | 2.4 | −2.7 | −3.3 | −2.1 |
| 740 | +0.2 | +2.3 | +3.0 | +2.4 | +1.2 | +1.6 | +0.8 | +0.4 | −1.0 | −0.7 | −1.1 | −0.4 |
| 735 | +0.9 | +2.7 | +3.2 | +2.1 | +1.0 | +1.1 | +1.3 | +1.3 | +0.8 | +1.7 | +1.0 | +1.1 |
| | **II. q. WIND VELOCITIES IN METERS PER SECOND.** | | | | | | | | | | | |
| 760 | 6.4 | 6.0 | 6.7 | 6.9 | 7.9 | 7.8 | 6.5 | 6.6 | 8.1 | 8.9 | 6.8 | 6.7 |
| 755 | 7.3 | 7.6 | 7.8 | 7.6 | 8.1 | 7.6 | 7.3 | 8.7 | 10.2 | 10.8 | 8.4 | 9.4 |
| 750 | 10.0 | 9.1 | 8.7 | 7.2 | 8.5 | 7.8 | 9.0 | 10.8 | 11.0 | 11.4 | 9.8 | 10.7 |
| 745 | 11.9 | 10.3 | 9.4 | 6.8 | 8.2 | 8.0 | 11.1 | 11.6 | 11.0 | 11.5 | 10.8 | 11.2 |
| 740 | 12.6 | 10.8 | 9.9 | 7.3 | 7.9 | 7.8 | 10.9 | 10.4 | 10.4 | 11.3 | 11.1 | 11.1 |
| 735 | 12.6 | 11.0 | 10.1 | 8.5 | 8.2 | 7.6 | 9.3 | 9.6 | 10.2 | 11.5 | 11.2 | 10.7 |
| | **III. −i. THE ANGLE WITH THE ISOBAR.** | | | | | | | | | | | |
| 760 | 47 | 45 | 37 | 40 | 42 | 29 | 54 | 55 | 49 | 44 | 39 | 51 |
| 755 | 44 | 46 | 41 | 42 | 45 | 35 | 54 | 51 | 46 | 40 | 36 | 51 |
| 750 | 43 | 46 | 44 | 43 | 46 | 41 | 54 | 48 | 43 | 38 | 35 | 52 |
| 745 | 43 | 44 | 45 | 41 | 46 | 44 | 53 | 45 | 41 | 35 | 34 | 50 |
| 740 | 44 | 41 | 39 | 39 | 45 | 43 | 50 | 42 | 39 | 33 | 34 | 45 |
| 735 | 46 | 38 | 35 | 37 | 45 | 40 | 47 | 39 | 38 | 31 | 34 | 39 |

The data of Table 83 are transferred to fig. 18, which presents a circular cyclone equivalent to those selected on the charts. Lines are drawn thru the points of equal temperature disturbances. *The 0 disturbance is on a line nearly north and south thru the center, the greatest cold is on the southwest edge of the 760 isobar and the warmest area covers the southeast quadrant.* On comparing fig. 18 with MONTHLY WEATHER REVIEW, February, 1906, 34, figs. 5 to 10, it is seen that they are in harmony. It is evident that similar careful computations of the temperature distributions should be made on every 1,000-meter level, and it is inferred that the asymmetrical arrangement found in the discussion of 1906 will be substantially confirmed in all the levels, tho of course the details will be greatly improved. The concentration of the cold area in the cyclone is more pronounced than is that of the warm area, which is spread quite uniformly over the eastern sectors, but there is no tendency for one system to intrude upon the other, and the evidence is decisive that there is no warm-centered cyclone in the lower levels of the United States.

The wind vectors call for no special comment except that in the process of composition, whereby the elongated or elliptical isobars are rendered circular, the two independent streams of warm and cold air, respectively, are obscured except for the cold and warm areas that have been described. In the individual cyclones it is easy to see that the cold current tends to underrun the warm currents, and this is shown in part by the fact that the vectors of the cold current are nearly at right angles to the vectors of the warm current in the south to southeast quadrant. This same condition is also shown in the northern quadrant where the warm current tends to overrun the cold current, tho this is more confused by the interaction with the eastward drift and the composition of forces taking effect over the barometric "saddle" in that region. In the southern quadrant the motions of the cyclone and the eastward drift are generally in about the same direction, northeastward for both currents, while in the northern quadrant they are counter directed and the relative changes in direction are pronounced.

THE COMPONENT VELOCITIES IN THE HIGHER LEVELS.

The campaign during the international cloud year 1896–97 was conducted on the part of the Weather Bureau with the special object of determining as accurately as possible the radial ($u_2$) and tangential ($v_2$) components of the velocity in cyclones and anticyclones proper, as distinguished from the meridional ($u_1$) and the longitudinal ($v_1$) components of the velocity due to the circulation in the general vortex of the hemisphere taken by itself. A very large number of observations were available, more than 6,000, and special care was taken to separate these components as thoroly as possible. It is evident that the data employed were derived from all sorts of circulations, such as occurred in that year, and that it would not have been possible to sort it out in such a way as to separate that belonging to *strongly* developed cyclones and that pertaining to an aimless form of the circulation. It is evident that our computations should properly be limited to include only firmly formed cyclonic circulations, if it were possible to do so. On this account the derived components ($u_2$ $v_2$) are not very reliable as to details in all the levels, and they need to be supplemented by numerous observations extending over many years. The discussion of the Weather Bureau data can be found in Chapters 6 and 7 of the Cloud Report, and some further remarks upon its significance occur in Chapter 11. Our special concern at this time is with the summary of the data in Table 126, page 626, which will be the basis of the following considerations.

It will be noted that we are dealing with the same system of radial distribution, as may be seen by comparing Table 77 of this paper with the radial distances I, II, III, of the Cloud Report, Table 126.

| *Table 126.* | | *Table 77.* | |
|---|---|---|---|
| III. | 1250000 | 760 | 1250000 |
| II. | 750000 | 750 | 733000 |
| I. | 250000 | 740 | 300000 |

It is evident that by plotting the three points given in

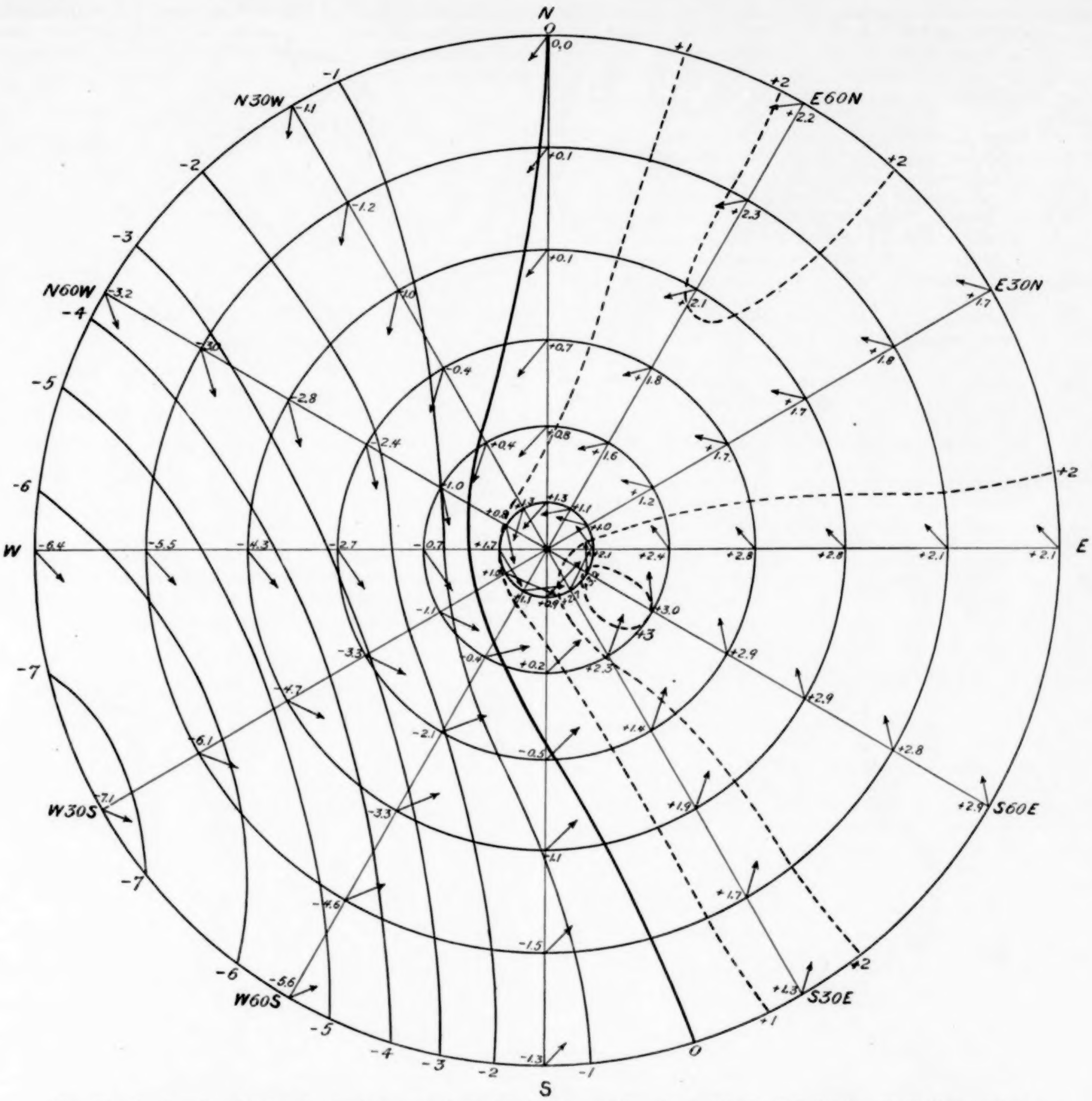



FIG. 18.—Land cyclone having circular isobars equivalent to the elongated cyclone of the United States, with the temperature distribution and the wind vectors, the center being located in the Ohio Valley. Compare the weather map, March 6, 1908.

Cloud Report, Table 126, for the $u_2$ and $v_2$ components on each level there will be no difficulty in constructing diagrams which determine approximately the average values of these components in a normal system. Attention has been paid to placing the values of $u$, $v$, from Table 81, II, at the basis of this cyclonic system and enlarging the values $u$, $v$, derived from the diagrams because they are doubtless smaller than should prevail in highly-developed vortices, as already explained. It has been found necessary to rectify the $v$ component only a little in the several levels. The $u$ component is much more difficult to secure from direct observations, and it is less reliable, so that the modifications are greater. What are supposed to be the most probable values of the $u$ components have been extracted from the diagrams for use in the following computations. Table 84, I and II, contain these adopted values of the $u$ component and $v$ component corresponding with the lines commencing on the 5-millimeter-spaced isobars of 760 to 735. It was stated in the Cloud Report that the values of $u_2$, $v_2$, there deduced were in the proper form for use in the equations of motion. It has been already pointed out that the $u_2$ component in the upper levels is of the same sign as in the lower levels, thus differing from the usual supposition made regarding this component which assumes that the radial component in the high strata should be directed outwards, as is common in the dumb-bell-shaped vortex.

TABLE 84.—*The observed radial ($u$) and tangential ($v$) components of the velocity derived from Table 126 of the Cloud Report.*

I. $u$=THE OBSERVED RADIAL VELOCITIES.

| Height. | 1250000 (1) 760 | 975000 (2) 755 | 733000 (3) 750 | 508000 (4) 745 | 300000 (5) 740 | 80000 (6) 735 |
|---|---|---|---|---|---|---|
| *Meters.* 10,000 | −0.5 | −0.7 | −1.0 | −1.3 | −1.6 | −2.0 |
| 9,000 | −1.5 | −2.1 | −2.7 | −3.0 | −3.7 | −4.5 |
| 8,000 | −2.0 | −3.0 | −4.0 | −4.5 | −5.5 | −6.0 |
| 7,000 | −3.0 | −4.0 | −5.0 | −6.0 | −7.0 | −7.5 |
| 6,000 | −3.0 | −4.0 | −5.0 | −6.0 | −7.0 | −8.0 |
| 5,000 | −2.5 | −3.0 | −4.0 | −4.5 | −6.0 | −7.0 |
| 4,000 | −2.0 | −2.5 | −3.0 | −4.0 | −5.0 | −6.0 |
| 3,000 | −2.0 | −2.0 | −2.0 | −2.5 | −3.5 | −4.5 |
| 2,000 | −2.0 | −2.0 | −2.0 | −2.0 | −2.0 | −2.0 |
| 1,000 | −3.5 | −3.5 | −4.0 | −4.0 | −4.0 | −4.0 |
| 000 | −4.5 | −5.0 | −6.0 | −6.5 | −6.5 | −6.0 |

II. $v$=THE OBSERVED TANGENTIAL VELOCITIES.

| Height. | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| 10,000 | +2.0 | +2.5 | +3.0 | +4.0 | +4.5 | +5.0 |
| 9,000 | +4.0 | +6.0 | +8.0 | +8.5 | +8.5 | +9.0 |
| 8,000 | +4.0 | +7.0 | +10.0 | +12.0 | +12.0 | +11.0 |
| 7,000 | +5.0 | +10.0 | +13.0 | +14.0 | +14.0 | +14.0 |
| 6,000 | +6.0 | +11.0 | +14.0 | +15.0 | +15.0 | +16.0 |
| 5,000 | +7.0 | +12.0 | +15.0 | +16.0 | +18.0 | +19.0 |
| 4,000 | +7.0 | +11.0 | +14.0 | +17.0 | +19.0 | +21.0 |
| 3,000 | +6.0 | +10.0 | +13.0 | +16.0 | +19.0 | +23.0 |
| 2,000 | +5.0 | +9.0 | +12.0 | +15.0 | +18.0 | +22.0 |
| 1,000 | +5.0 | +6.0 | +8.0 | +10.0 | +12.0 | +14.0 |
| 000 | +5.0 | +5.5 | +6.0 | +6.0 | +6.5 | +7.0 |

III. THE COMPUTED ANGLE $-i$, TAN $(-i)=\frac{-u}{v}$.

| Height. | (1) | (2) | (3) | (4) | (5) | (6) | Mean. | $az$. |
|---|---|---|---|---|---|---|---|---|
| *Meters.* | ° ′ | ° ′ | ° ′ | ° ′ | ° ′ | ° ′ | ° | |
| 10,000 | −14 02 | −15 39 | −18 26 | −18 00 | −19 34 | −21 48 | −18.0 | 72.0 |
| 9,000 | −20 33 | −19 17 | −18 39 | −19 26 | −23 31 | −26 34 | −20.3 | 69.7 |
| 8,000 | −26 34 | −23 12 | −21 48 | −20 33 | −24 37 | −28 37 | −24.2 | 65.8 |
| 7,000 | −30 58 | −21 48 | −21 02 | −23 12 | −26 34 | −28 11 | −25.3 | 64.7 |
| 6,000 | −26 34 | −19 59 | −19 39 | −21 48 | −25 01 | −26 34 | −23.3 | 66.7 |
| 5,000 | −19 39 | −14 02 | −14 56 | −15 43 | −18 26 | −20 14 | −17.2 | 72.8 |
| 4,000 | −15 57 | −12 48 | −12 06 | −13 14 | −14 45 | −15 57 | −14.1 | 75.9 |
| 3,000 | −18 26 | −11 19 | −8 45 | −8 53 | −10 26 | −11 04 | −11.5 | 78.5 |
| 2,000 | −21 48 | −12 32 | −9 28 | −7 36 | −6 20 | −5 12 | −10.5 | 79.5 |
| 1,000 | −34 59 | −30 15 | −26 34 | −21 48 | −18 26 | −15 57 | −24.7 | 65.3 |
| 000 | −41 59 | −42 16 | −45 00 | −47 17 | −45 00 | −40 36 | −45.5 | 44.5 |

Table 84, I, contains the radial velocities, $u$, as derived from the cloud observations of 1896–97, Section II, the corresponding tangential velocities $v$, and Section III, the angle $-i$, direction inward at all points. The vortical characteristics of the tangential velocities appear most distinctly on the 2,000 to 4,000-meter levels, but it is very evident that these velocities do not conform to the dumb-bell-shaped vortex in any satisfactory manner. This is also seen in the values of the angle $-i$, which begin at $-45°$ at the surface, decrease to $-11°$ at 3,000 meters, rise to $-25°$ at the 7,000-meter level and fall to $-18°$ at the 10,000-meter level. The inward angle at the bottom of the vortex is not converted into an outward angle in the upper part of the vortex, but there is an inflow at all levels, most vigorous at the surface, least at the 3,000-meter level and passing thru another maximum at the 7,000-meter level. The values of $az = 90° - i$ go thru the counterpart values.

TABLE 85.—*The computed values of* $aA$.

$$aA=\frac{v}{\varpi \sin az}=\frac{-u}{\varpi \cos az}.$$

| Height. | 1250000 (1) 760 | 975000 (2) 755 | 733000 (3) 750 | 508000 (4) 745 | 300000 (5) 740 | 80000 (6) 735 |
|---|---|---|---|---|---|---|
| *Meters.* 10000 | 165 | 266 | 431 | 828 | 1593 | 6732 |
| 9000 | 342 | 652 | 1152 | 1775 | 3091 | 12577 |
| 8000 | 358 | 781 | 1469 | 2523 | 4401 | 15659 |
| 7000 | 467 | 1105 | 1900 | 2998 | 5217 | 19852 |
| 6000 | 537 | 1201 | 2028 | 3180 | 5518 | 24801 |
| 5000 | 595 | 1269 | 2118 | 3270 | 6325 | 25306 |
| 4000 | 585 | 1157 | 1953 | 3439 | 6548 | 27298 |
| 3000 | 506 | 1046 | 1794 | 3187 | 6441 | 29300 |
| 2000 | 431 | 946 | 1659 | 2978 | 6040 | 27598 |
| 1000 | 488 | 713 | 1220 | 2120 | 4216 | 18198 |
| 000 | 538 | 762 | 1158 | 1741 | 3064 | 11524 |

The unit=0.000 000 01 $=1\times 10^{-8}$

THE COMPUTED VORTEX LINES $aA$.

In order to obtain further information regarding the structure of this cyclonic circulation, we derive from the formulas of the dumb-bell-shaped vortex,

$$aA=\frac{v}{\varpi \sin az}=\frac{-u}{\varpi \cos az}.$$

We can proceed to compute the velocities from the terms $a$, $A$, $\varpi$, and $az$, if these are known, or we can compute $aA$ from $v$, $u$, $\varpi$, and $az$, if these are available. In Tables 77 and 84 all the latter data are to be found, and from them the values of $aA$ are computed. This work has been performed and the results are given in Table 85. It does not appear from the values of $az$ in Table 81, III, that $a$ can be taken out as a constant, so no attempt is made to separate the terms in $aA$. The maxima in the middle levels occur higher up in the outer than they do in the inner parts, and the values of $aA$ are very much greater near the axis. If these values of $aA$ are plotted on a diagram and lines are drawn thru the equal values of $aA$, taking as the initial values those occurring at the surface on the adopted lines (1), (2), (3), (4), (5), (6), we shall have a system like that in fig. 19. This is a remarkably suggestive structure and will require much careful consideration. The curvature is concave toward the axis, instead of convex as in the hurricane and tornado, the lines are crowded together in the outer rather than in the inner parts of the vortex. In these respects the system is quite the reverse of the ordinary dumb-bell vortex and suggests for the $aA$ lines a current function,

$$\psi = A\,\varpi^2 \cos az,$$

rather than that adopted for the tornado,

$$\psi = A\,\varpi^2 \sin az,$$

both satisfying the differential equation (23).

If fig. 19 is turned upside down and the axis is transferred to the right-hand side of the lines, the structure resembles a dumb-bell vortex. The concentration is at a distance from the axis rather than near it, and the lines are farther apart as the axis is approached in the observed cyclone. At the surface and up to 2,000 meters there is a small departure from the geometrical system, so that evidently the spacing of the lines as given by the isobar system on the weather charts is not in conformity on the outer lines (1), (2), to the remainder

of the structure. If we could imagine the cyclone to be surrounded by a cylinder, and the *wall of the cylinder to act as an axis*, then the computation would proceed as in the case of a central axis, so far as the spacing of these lines is concerned.

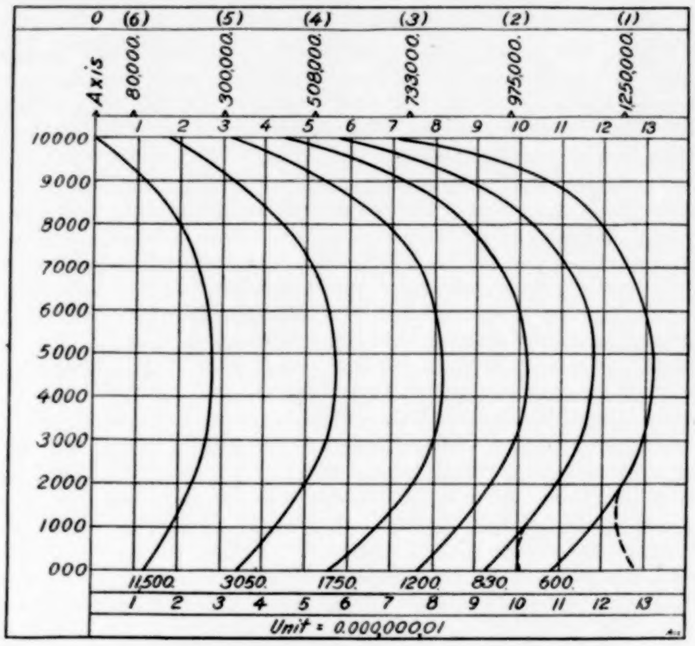



FIG. 19.—The computed vortex lines $aA$ of the asymmetric land cyclone.

THE CONCAVE DUMB-BELL-SHAPED VORTEX.

The preceding discussion of the vortex lines, which involved the computation of the product of two constants $a\ A$, $a$ being about 0.10 and $A$ being a constant on each vortex line but having different values on the different lines, has resulted in a vortex system which suggests a convex dumb-bell-shaped vortex, where the lines are concave toward the axis instead of convex, as in the tornado and the hurricane. These two vortices satisfy the equations of motion as follows:

| | Convex vortex. | Concave vortex. |
|---|---|---|
| Current function, | $\psi = A\varpi^2 \sin az$. | $\psi = A\varpi^2 \cos az$. |
| Radial velocity, | $u = -Aa\varpi \cos az$. | $u = +Aa\varpi \sin az$. |
| Tangential velocity, | $v = +Aa\varpi \sin az$. | $v = +Aa\varpi \cos az$. |
| Vertical velocity, | $w = +2A \sin az$. | $w = +2A \cos az$. |

It is easy to trace out the relative differences by simply interpreting the trigonometrical signs. In the concave vortex the radial velocity is zero for $az = 0°$, increases outward to $az = 90°$, and returns to zero for $az = 0°$. The tangential velocity begins at a maximum for $az = 0°$, decreases to zero for $az = 90°$, and increases again to the maximum. The vertical velocity begins at a maximum for $az = 0°$, decreases to zero for $az = 90°$, and then increases to a maximum; $v$ and $w$ reverse direction at $az = 90°$. Whether this is a possible vortex in the atmosphere is a question which does not need to be considered in this connection for the following reasons. When one attempts to match the observed angles $i$ of Table 84 III with the lines of fig. 19, as was done by some computations, it is readily seen that they do not in anywise agree in meeting the required conditions of the suggested concave vortex, and we must conclude that the suggested analogy is in fact fictitious and not very useful.

What we actually have in the cyclone is a convex dumb-bell-shaped vortex disturbed from normal conditions, and distorted almost beyond recognition by two fundamental circumstances. *The first is that the temperature distribution is entirely changed. In the hurricane the temperatures are stratified horizontally, but in the cyclone they are separated vertically, the warm and cold masses lying side by side, and the streams seeking to interpenetrate horizontally in the different levels by the action of gravitation. The second is the fact that the imperfect dumb-bell-shaped vortex which results from the preceding process attempts to lift its head into the rapidly flowing eastward drift which keeps stripping off the top layers and thus prevents the formation of the vortex in its natural proportions.* This process has been fully described in the MONTHLY WEATHER REVIEW, February, 1903, 31, fig. 28, where the scheme of the isobars and wind vectors is developed. I therefore interpret fig. 19, above, to mean that it represents a convex dumb-bell-shaped vortex struggling to establish equilibrium between masses of different temperatures on the same levels, while the top layers are continuously stript away in the eastward drift. The inward radial velocity which properly belongs to the lower sections of a perfect dumb-bell-shaped vortex continues to prevail as long as there is any tangential velocity surviving, *because the lower half of the dumb-bell-shaped vortex is in fact never completed in this cyclonic circulation.* It is really a nameless survival of this typical vortex, and is a succession of hydrodynamic circulations more due to mutual reactions of warm and cold streams on the same horizontal plane, than to any total vortex structure involving mutual dependencies thru great depths. It is a question whether these cyclonic circulations can ever be analyzed as a vortex structure of any given type, as has always been assumed to be the case in the general discussions which prevail in meteorological literature. *Certainly there is no prospect of settling this problem until such accurate discussions of the observations of temperature, pressure, and wind vectors become available in all the levels as are given for the surface in fig. 18 of this paper.*

As a matter of fact it is exceedingly difficult to secure the correct values of the radial velocity $u$ in the upper levels, as is abundantly testified by the work in the Cloud Report of 1896–97. In that place the motions of all sorts of cyclones, large and small, whether fully or incompletely developed, were united in one composite. Evidently for the study of this vortex problem in the upper levels only the strong cyclones should be used so that the data on the upper levels may be comparable with the data of fig. 18. In case the velocities of the Cloud Report, Table 126, adopted to extend the discussion above the surface, are not representatively correct the conclusions of this paper must be modified, but it is certain that no superficial treatment of the data of cyclones and anticyclones in the upper levels suffices to form the basis of our theoretical discussion. The cyclonic components $u_2$, $v_2$, must be fully separated from the eastward drift $u_1$, $v_1$, in all the levels, and a continuous campaign of observations with nephoscopes and theodolites, extending over several years, seems to be demanded by this branch of meteorological science.

## DRY FARMING.

The expression "dry farming" has come into prominence during the last three years, and the "Third Trans-Missouri Dry-farming Congress," held at Cheyenne, Wyo., February 23–25, 1909, was the occasion of an enthusiastic presentation of the methods and the success attaching to this new departure. The term "dry farming" itself may be considered as an abbreviation of the expression "dry-land farming." The general idea of the method consists in giving up the attempt to raise a crop every year continuously on a given piece of land, and attempting instead of that to so conserve and utilize the moisture that the land receives from rain and snow as to secure a crop once every two or three years.

Few persons realize that the great success of the pioneers in a semiarid country depended upon their having the accumulated moisture stored up in the soil for many years upon which the first crops could feed. After a few years this accumulation is reduced below the ability of the annual precipitation to meet the demand made upon it, and either artificial irriga-

tion must be resorted to or else the farmer suffers great loss in dry years and secures a good crop only in a wet year. Dry farming attains the same average results as ordinary farming without irrigation, but with the great advantage that the farmer's crops are fairly uniform thruout the successive years and he avoids the harrowing habit of worrying over frequent droughts and the necessity of borrowing money to tide him over the loss of crops.

The methods adopted in dry farming vary in every community with the climate, the soil, and the plant to be cultivated, and it is beyond our province to enter into the details of this side of the subject. On the other hand the climatic features that render dry farming possible and wise depend essentially upon the annual quantity rather than the seasonal distribution of precipitation and evaporation. This feature belongs to climatology proper.—*C. A.*

## SOME CLIMATIC FEATURES OF WYOMING, AND THEIR RELATION TO DRY FARMING.[1]

By W. S. PALMER, Section Director. Dated Cheyenne, Wyo., February 24, 1909.

That portion of our country which is commonly spoken of as the semiarid region, and where so-called dry farming is practised, embraces a large territory which is included between the 95th and 125th degrees of longitude west of Greenwich. Within that belt of 30 degrees of longitude can be found a vast variety of climates; its topography is such that along its northern border winter temperatures of from 50° to 60° below zero may be experienced at times, while during the summer temperatures as high as 120° above zero may be recorded in the deserts of Arizona and southern California. There is, also, a great variation in the average annual precipitation of the various sections of this region, for in some of the mountain districts or along the Pacific coast the annual amounts may exceed 50 inches, while some of the desert regions have annual averages of less than 5 inches. On account of the broad area embraced within this region and the various climates that may be found therein, I wish to discuss in detail the climate of but a small portion of the semiarid region, so I shall confine my address to a discussion of some of the climatic features of Wyoming, a subject which has received my special study during the last ten years or more. While my remarks will be confined mostly to a discussion of the climate of Wyoming, they will, in general, apply to a large portion of the country which is now being cultivated by the so-called dry-farming method, Wyoming being located near the center of the dry-farming belt of the West.

During the last seventeen years a systematic collection of weather data has been made in Wyoming. In addition to the weather records which have been kept at the regular Weather Bureau stations where commissioned men are stationed, a large number of valuable records have been kept by persons who have been supplied with standard instruments by the Government and who have cooperated with the Weather Bureau in this work. The value of these records which have been voluntarily kept by the cooperative observers can not be overestimated, as they furnish data from the sections of the State where there are no regular Weather Bureau stations.

### PRECIPITATION FOR WYOMING.

The most essential element in the success of dry farming is moisture, and I wish to present to you some Wyoming records regarding precipitation. From the monthly reports which have been compiled in the Cheyenne office from records kept at stations distributed over nearly all sections of the State, it has been determined that the average precipitation for the State as a whole during the last seventeen years has been 13.68 inches, or a trifle more than 13.50 inches. This average does not take into consideration the heavy precipitation which may fall in the high mountain districts where very few reliable records have ever been kept, but it is a fair average for that portion of the State below 8,000 feet, or for all of those districts where cultivation is possible. The precipitation herein spoken of includes rainfall and snowfall, the latter being reduced to its water equivalent.

[1] Paper presented to Third Trans-Missouri Dry-farming Congress at Cheyenne, Wyo., February 24, 1909.

### *Geographical distribution of the precipitation.*

While the average amount for the State is 13.68 inches, there is a wide variation in the normal amounts received over the various sections of the State. There are portions of Big Horn and Sweetwater counties where the average annual precipitation is probably less than 5 inches, while over the extreme northeastern and the extreme northwestern portions of the State there may be a few sections where the annual average is nearly 20 inches. On a map which I have prepared to accompany this paper, see fig. 1, I have endeavored to show the geographical distribution of the annual rainfall thruout Wyoming; the peculiar and complicated topography of the State causing a wide variation over the various sections. The unshaded portions of the map show areas of the State where the average annual precipitation is less than 10 inches, and you will notice that those areas embrace only portions of Big Horn County and the Red Desert region, the aggregate of which is only a small percentage of the total area of the State. I believe that most of the dry-farming experts of to-day do not advise that dry farming be attempted in regions where the annual precipitation is less than 10 inches, so the unshaded portions of the map show regions where dry-farming attempts should not be made at the present day. The darkest shadings represent areas where the average annual precipitation is in excess of 15 inches, and here again you will notice that these areas represent only a small percentage of the total area of the State. It is probable that about 75 per cent of the total area of the State is embraced within the region which receives from 10 to 15 inches annually, such areas being represented on the map by a light shading. Thus you can see that a large proportion of this State receives an average annual rainfall sufficient, so we are told by the dry-farming experts, for the successful growth of certain crops where proper methods of cultivation are followed.

### *Seasonal distribution of rainfall.*

From the large number of monthly records which have been compiled at the Cheyenne office, covering a period of seventeen years, I have computed the average monthly precipitation for each month of the year, and have shown the amounts graphically on the accompanying chart, fig. 2. It will be noticed that the monthly amount of precipitation increases from January to May, which has the highest average of any month of the year; a gradual decrease in the monthly amount is noted from May to November which shows the lowest average for the year. From fig. 2 it can readily be seen that in this section of the semiarid region the rain falls during that time of the year when it is most needed for the crops, that is, about 70 per cent of the total annual amount falls during the six months, March to August, inclusive. There is some variation in the average amounts for the different seasons in the different sections of the State. I give below for a number of selected stations, the percentage of the total annual averages which falls during the six months, March to August:

| Station. | County. | Percentage which falls March to August. |
|---|---|---|
| Cheyenne | Laramie | 75 |
| Buffalo | Johnson | 75 |
| Fort Laramie | Laramie | 73 |
| Laramie | Albany | 72 |
| Sheridan | Sheridan | 68 |
| Lander | Fremont | 66 |
| Bedford | Uinta | 55 |
| Evanston | Uinta | 54 |
| Border | Uinta | 54 |
| Yellowstone Park | National Park | 50 |

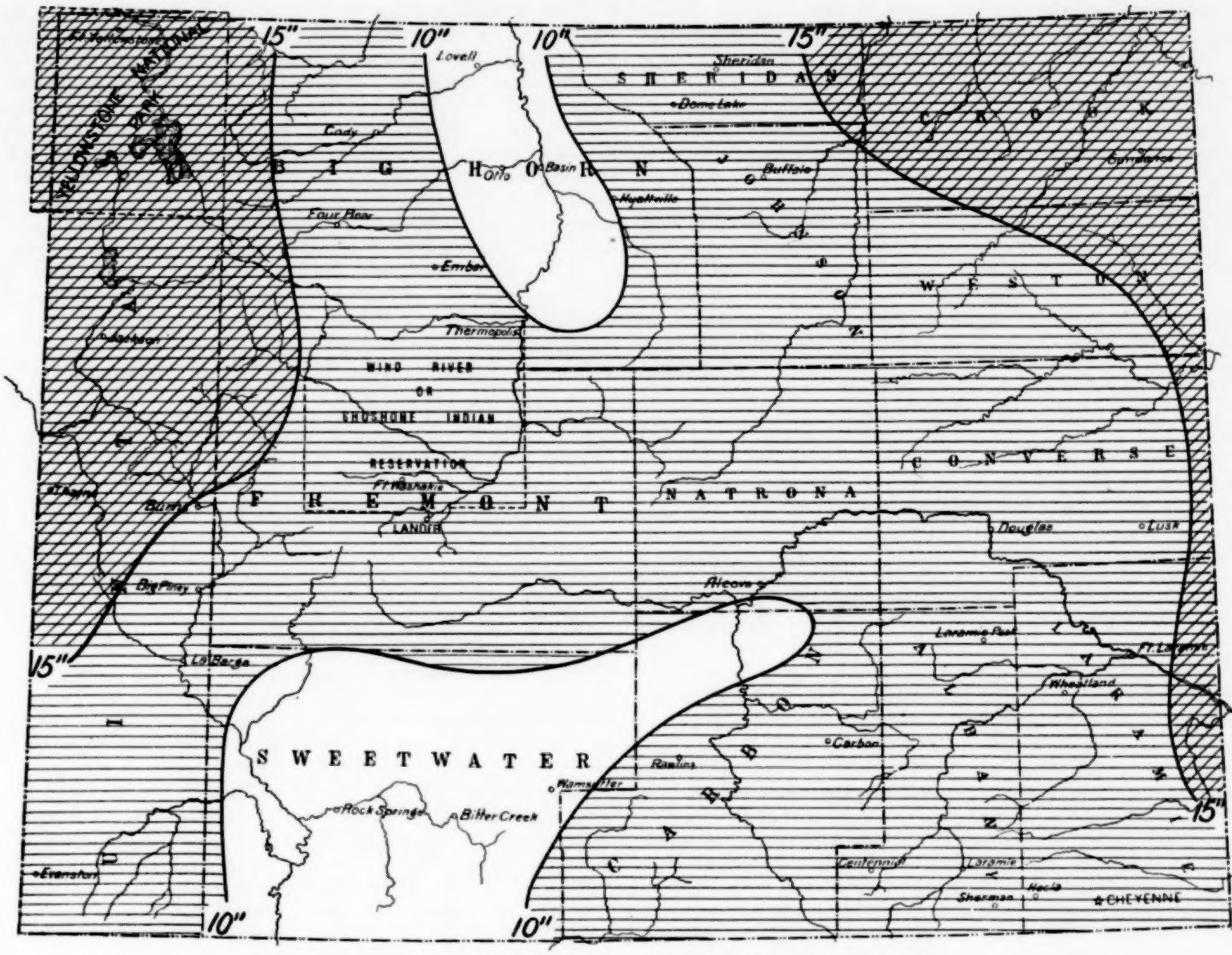



FIG. 1.—Map of the average annual precipitation over Wyoming.

From the above, it will be seen that amuch greater proportion of the average annual precipitation falls during the six months period, March to August, over the eastern portion of the State than over the western counties. In Utah, less than 40 per cent of the average annual precipitation falls during that period.

*Reliability of the spring precipitation.*

The April–May precipitation for the State is a very reliable factor. During the last twenty-eight years there has been but one year during which the precipitation at Cheyenne has not been in excess of 2.50 inches for the two months, April and May, and that was in 1886, when it amounted to only 1.44 inches.

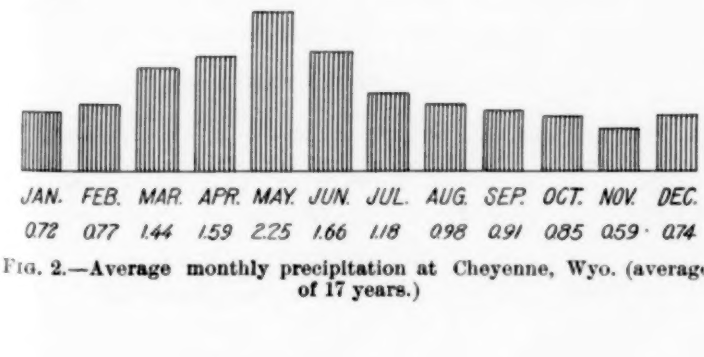



FIG. 2.—Average monthly precipitation at Cheyenne, Wyo. (averages of 17 years.)

TEMPERATURE CONDITIONS OF WYOMING.

The varied topography of the State gives a wide variation in the temperature conditions of the various sections of the State. In some sections the growing season is from four to five months in duration and summer temperatures rise to 95° or 100°, or even higher; over some of the higher agricultural districts the growing season is short, summer temperatures never rise above 95°, frosts may be experienced in any month, and only the hardier grains and vegetables can be successfully grown.

SUNSHINE.

The percentage of sunshine in Wyoming is much in excess of the percentage which is received thruout the Mississippi Valley, and this excess of sunshine is a very important factor to be considered when discussing the agricultural possibilities of the semiarid region. The actual number of hours of sunshine which a plant receives during its growing period has never, I believe, received its proper share of consideration when the length of the growing season has been under discussion; other conditions being the same, that plant will make the best progress and development which receives the greatest amount of sunshine. The percentage of sunshine received thruout the central and upper Mississippi Valley is about 45 per cent of the possible amount; in Wyoming and most of the semiarid region the percentage is 60 or above. That is, for every three hours of sunshine which is received in the Missis-

sippi Valley we receive four or more in this section of the country. Thus, if we consider the progress which should be made by growing crops by considering only the one climatic element, sunshine, the crops in the semiarid region should make as much progress in three months as the same crops would make in four months in the Mississippi Valley. I believe that the high percentage of sugar in the beets raised in this western country is due to the high percentage of sunshine which they receive during their period of growth. I do not wish to carry the discussion of this subject further, but I wish to say again that I believe that this subject has not received the consideration that it should.

SEED BREEDING.

The seedsmen of the northern districts of this country have always contended, and with good reason, that northern-grown seeds are the best; to this the seedsmen of the western districts should add that the higher the elevation at which seeds are grown, other conditions being identical, the better will be the seeds. The dry farmer can, with equally as good reason, contend that the seeds which are produced with the minimum amount of moisture for their successful production are superior to the seeds which have been grown where an excess of moisture has been used. That section of the country which combines the three conditions, namely, a northern latitude, a moderate elevation above the sea level, and a rainfall not in excess of the actual needs of plant growth, should prove to be a place where the very highest class of seeds can be produced.

EXTENSION OF FARMING DISTRICTS.

The farming belt of this country was a few years ago brought to the eastern edge of the semiarid region and within the last few years it has been rapidly covering, by irrigation and so-called dry-farming methods, large areas of what was once known as the Great American Desert. Crops are being successfully and profitably produced in regions where a few years ago it was considered that the precipitation was not sufficient to raise crops. This has not been due to a change in the climate of any part of our country, because the life of man is too short to see any change in the climate of any section; the weather of the successive years may and does vary somewhat, but our climatic conditions persist. Man has been learning how to conserve the moisture which falls, and to adapt the proper crops to the conditions of a limited rainfall. These are two lines of study which must be carried along until all of the available lands of our country, even in regions of a rainfall of less than 10 inches, can be successfully used for the production of some kind of a crop.

## ATTENDANCE ON SCIENTIFIC MEETINGS.

By W. J. Humphreys, Professor of Meteorological Physics. Dated Washington, January 26, 1909.

The phenomena and the processes of nature are so interdependent, and the methods of investigating them so numerous, that only he is prepared to work in any science to greatest purpose who has a sympathetic appreciation for all sciences, and an increasingly minute knowledge as his own specialty is more nearly approached. There is no exaggeration in the statement that he needs to know everything about something and something about everything, for nothing short of this can give him that accuracy and that resourcefulness essential to the solution of difficult problems, nor that alertness and breadth of view so necessary to the detection and to the understanding of new phenomena.

These statements, while universally true, apply with peculiar force to meteorology which, besides demanding a knowledge of mathematics and of every branch of physics, in one way or another comes in the closest touch with astronomy, geology, chemistry, and biology, and with practically every other science, so extensive and so profound are the effects of its phenomena. And because of this intimate relation to so many sciences, it is especially important for the meteorologist to prepare articles for and to attend such important meetings as those of the American Association for the Advancement of Science, of the affiliated national and of other societies, for there are sure to be read at these meetings many papers of interest to him, and besides his own contributions are certain to receive all that attention and respect they deserve. But far better than the information he will get from the papers he will hear, or from the discussion of his own, will be the effect upon him of the enthusiasm inspired by the association thus secured, even tho temporary, with the productive scholars of the entire country; an enthusiasm that welcomes scientific difficulties and leads, thru persistent attack, to their ultimate solution.

Any one, whether public official or private citizen, whose position presupposes scholarship, and gives him an opportunity to work—and in this connection opportunity implies duty—and who does not, whenever practicable, attend such meetings, by his absence makes the absurd declaration that he can work as well without encouragement as with it; that enthusiasm to him is useless; and that acquaintance and association with the world's best scholars can do him no good, or else confesses that, neither taking part in creative work nor caring for it, he is an intellectual sluggard blocking, so far as one man can, the world's progress by filling a position for which he is utterly unworthy.

In the name of every art and of the science that is back of it, in the name of civilization and of all human progress, let no position that offers the sacred privilege of doing work be filled save by him who realizes his duty.

It would be absurd, of course, to claim that to become a productive scholar it is sufficient to attend these gatherings of scientific men (exceptional native ability, wisely and persistently trained, is the only means to such an end), but it can not be emphasized too strongly that wherever bonds outrank brains, wherever society fads pose as scientific facts and meaningless gibberish passes for profound learning, such meetings, by furnishing the encouragement his sensitive nature craves, prolong the scholar's active period and increase both the quantity and the quality of his work.

These are some of the reasons in general terms why the writer urges fuller assemblages of all scientific men. But for any meteorologist who may be disposed to ask for more specific information as to how he could be benefited, the following list of papers, selected from the many read at Baltimore before the various societies during the convocation week of December, 1908, is appended. It is not a complete list, for there were other papers the meteorologist might do well to read; but it is extensive enough to show that his branch of geophysics was not neglected, even if he himself did chance to be absent.

Prof. Edward L. Nichols. Science and practical problems of the future. (Address of the retiring president.)

Prof. Dr. Albrecht Penck, Berlin University. Man, climate, and soil. (Public address.)

Maj. G. A. Squier, U. S. A. Recent progress in aeronautics. (Public address.)

F. R. Moulton. On certain implication of possible changes in the form and dimensions of the sun, and some suggestions for explaining certain phenomena of variable stars.

Phillip Fox and Georgio Abetti. The interaction of sun-spots.

A. Galline. On the diurnal variations in the intensity of the penetrating radiation present at the surface of the earth.

John Zeleny and L. W. McKeehan. An experimental determination of the terminal velocity of fall of small spheres in air.

G. E. Hale. Solar vortices and magnetic fields.

L. A. Bauer. A plea for terrestrial and cosmical physics.

John F. Hayford. Ellipticity of the earth is not a proof of a former liquid state.

J. E. Siebel. The thermodynamics of saturated vapors.

Henry E. Wetherill. The lumeter, a practical measure of general luminosity.

W. W. Strong. Ionization in closed vessels.

Alois F. Kovarik. Velocity of the negative ions produced by ultraviolet rays in various gases at different pressures and temperatures.

F. E. Nipher. Momentum effects in electrical discharge.

L. A. Bauer. Regarding recent magnetic storms.

W. J. Humphreys. Solar magnetism.

W. J. Humphreys. The upper inversion.

R. B. Dole and H. Stabler. Denudation in the United States.

Eugene C. Bingham. The relations between viscosity and fluidity.

E. W. Washburn. A simplification of the cyclic-process method for deriving thermodynamic equations.

Irving Langmuir. The formation of nitric oxide by the action of nernst glowers on air.

R. G. Mailey. The properties of water near the critical point.

J. E. Mills. The internal heat of vaporization.

H. E. Patten. Heat conductance of soils.

Bohumil Shimek. A preliminary report of the result of observations on the relation of evaporation to the treelessness of the prairies.

Gifford Pinchot. The conservation problem.

L. A. Bauer. Status of the magnetic survey of the earth.

Henry Gannett. The climate of Cuba.

A. Lawrence Rotch. The temperature at great heights above the American Continent.

R. DeC. Ward. The cylconic unit in climatological investigations.

Ellsworth Huntington. The climate of the historic past.

Robert M. Brown. The reservoir system of flood protection in the light of the recent floods of the Mississippi River.

C. H. Shaw. Vegetation and altitude.

V. M. Spalding. Local distribution of desert plants.

E. N. Transeau. The relation of the climatic factors to vegetation.

Lawence Martin. The Alaskan earthquake of 1899.

Harry Fielding Reid. Mass movements in tectonic earthquakes.

Charles R. Keyes. Deflation and the relative efficiencies of erosive processes under conditions of aridity.

D. T. MacDougal. Relation of plants to climate with special reference to pleistocene conditions.

The most important thing, potentially, for meteorology that happened during the Baltimore meetings, was the reading by Major Squier, of his valuable paper on aeronautics, and the consequent decision, on the part of Section D, to make aeronautics and aerophysics prominent features at the next and subsequent meetings of the association.

Aeronautics is sure to stimulate, as never before, the study of the directions, the turbulence, and the other properties of wind currents, and at the same time to furnish the best means for solving these and kindred problems; so that it is not too much to say that a new meteorological era, new in the extent of its usefulness, and new in the rapidity of its advance, is at hand. And he who in any way contributes to this advance will have done something of the greatest good it is given man to do; for to that extent, be it much or be it little, because of his labors and of his discoveries, the world will be wiser and the energies of men more productive.

## A PROPOSED NEW FORMULA FOR EVAPORATION.

By C. F. Marvin, Professor of Meteorology. Dated March 21, 1909.

The attention of the writer has been called to the perplexities that have arisen in the discussion of evaporation observations at Reno, Indio, and elsewhere, whereby it seems that some factor influencing evaporation is missing, as it were. The whole subject is very fully discust by Professor Bigelow[1] in a series of papers in the Monthly Weather Review.

The observations seem to indicate in certain cases that notably different amounts of evaporation are observed under seemingly the same meteorological conditions, or, that the same amounts of evaporation are found when the observed meteorological conditions are notably different. The writer has not had an opportunity to closely scrutinize the original data, but, with a view of bringing in a different and perhaps a new and independent line of thought on this problem, I have endeavored to take up *de novo* the general question of the evaporation equation. The results of this study are given in what follows.

Let us imagine we have a free surface of water, perfectly smooth, with dry air over it.

The kinetic theory of vapor tells us that molecules of water vapor are being continually shot out thru the superficial film of the water surface into the air above and beyond. Let us suppose, to start with, that these molecules are able to escape to an indefinite distance from the water surface so that they can not return. The water thus lost is the true or absolute evaporation that can take place under the given conditions. Now, we believe that there are only two conditions that can influence the amount of water thus evaporated. We know that if the water is warm the molecules are shot out faster than if it is cold. We also know that the greater the pressure or density of the air or gas over the water the slower will be the evaporation. Remembering that we have assumed that all the molecules shot out escape from the water entirely, we do not see that any other conditions can influence the absolute rate of evaporation. We recognize, of course, the effects of impurities in the water, etc.

If $T_s$ is the water surface temperature, and $B$ is the atmospheric pressure, then the conclusion we have just stated may be represented, mathematically, by the expression:

$$\text{Absolute evaporation, per unit of time, varies as } \frac{T_s}{B}.$$

Our assumed conditions, however, do not represent any ordinary state in nature. The molecules shot out from the water can not all escape. They collide with each other and with the air particles so that their complete escape is quite impossible. In fact, much of the moisture evaporated becomes entangled in the thin layer of mixt air and vapor near the water, and many of the vapor particles in this layer shoot back into the water; consequently, the *apparent* evaporation, which is the only thing we can measure, and which now concerns us, is the difference between the vapor shot out from the water and that which returns from the overlying gaseous sheet.

The object now in hand is to formulate an equation that shall express as nearly as may be the relation between the surrounding conditions and this apparent evaporation. As we have already seen, the rate of evaporation will be greater and greater the higher the temperature of the water. It will also be greater the higher the temperature of the sheet of air and vapor over the water, because the higher this temperature the greater is the capacity of this space to receive and disseminate moisture. On the other hand the rate of evaporation will be less the greater the quantity of vapor already present in the overlying gaseous sheet. It will also be less the greater the gross barometric pressure. Finally, the more the wind blows the faster will dry air replace the moist and thus make faster evaporation possible.

[1] Bigelow, F. H. Monthly Weather Review, July, 1907, p. 311; February, 1908, p. 24; Summary, 1908, p. 437.

Now, these several relations can be represented mathematically by two essentially different expressions; namely, by appropriate ratios, or by the choice of suitable differences. For example, the fact that the rate of evaporation increases with the increase of water and air temperature and wind, but decreases with increase of barometric pressure and of the temperature of the dew-point is exprest by writing either:

(1) $$\frac{dE}{dt} \text{ varies as } \frac{T_s \times T_a \times V}{T_d \times B},$$

or

(2) $$\frac{dE}{dt} \text{ varies as } (T_s + T_a - T_d)\frac{V}{B},$$

or by some modification of these mathematical forms.

The first expression utilizes simply products and ratios; whereas, in the second these mathematical forms are combined with sums and differences. If we strike out of (1) the terms depending on barometer and air temperature, namely, $\frac{T_a}{B}$ and supply the terms $\frac{de}{ds}$ we get

(3) $$\frac{dE}{dt} \text{ varies as } \frac{T_s}{T_d} \cdot \frac{de}{ds} V.$$

This is essentially the Bigelow equation.

Similarly, by striking out the same terms $T_a$ and $B$ from (2), we get:

(4) $$\frac{dE}{dt} \text{ varies as } (T_s - T_d)\, V,$$

which is essentially the Dalton equation.

Both these equations disregard the barometer term, and omit the influence that the air temperature has on the evaporation.

Professor Bigelow has been led to the adoption of his equation by a very different line of thought from the one here followed and has extensively employed the ratio expression in the analysis of observations made at Reno, Nev., and Indio, Cal. Further on I shall discuss, with some fullness, the defects of both the above equations. At present I desire to convert the second form of expression given into an evaporation formula that will be more convenient for our use.

For very good reasons which need not be given at this time, it is inconvenient to use *temperatures* directly in the evaporation equation, and I therefore propose to substitute at once the more convenient and closely related, and equally important, saturation vapor pressures, namely:

$e_s$=saturation vapor pressures corresponding to $T_s$=water temperature.

$e_a$=saturation vapor pressures corresponding to $T_a$=air temperature.

$e_d$=saturation vapor pressures corresponding to $T_d$=dew-point temperature.

On this basis the expression (2) becomes:

(5) $$\frac{dE}{dt} \text{ varies as } (e_s + e_a - e_d)\frac{V}{B}.$$

No equation for evaporation can be accepted that does not give us *zero* evaporation under those conditions in which physics teaches us that the evaporation must be zero.

The fundamental conditions under which the apparent evaporation will be zero are simply these. The temperature of the air over the water must be the same as that of the water and the space must be saturated with vapor. We may state this in other words by saying that the state of equilibrium in which the apparent evaporation is zero is established only when the temperature of the water, the temperature of the air, and the temperature of the dew-point, all come to a perfect identity. If the wind blows and brings in new air, this must be saturated and at the same temperature, otherwise either evaporation or condensation will take place.

The only thing that it is necessary to do to make our expression (5) satisfy this fundamental requirement is to place the coefficient *2* before the factor $e_d$. In fact, we may write the equation at once in the following form:

(6) $$\frac{dE}{dt} = \frac{C}{B}(e_s + e_a - 2e_d) f(e) f(v).$$

The new and important feature presented in this equation is the expression or term which we write:

(7) $$e_s + e_a - 2e_d = p.$$

This term has all the qualities of a thermodynamic difference of potential for evaporation, and I think we may call it the evaporation potential.[2] As its values rise or fall, or become zero, positive or negative, so the evaporation is great or little, zero, or positive or negative.

This is clearly brought out in the following examination of the expression:

Suppose the air and water are both warm and the air absolutely dry, $e_a$ and $e_s$ are then both large, and $e_d=0$; whence the potential will have a large value, and thus satisfy the physical demands which call for a large evaporation under the conditions assumed. If we imagine the moisture to accumulate in the air, than $e_d$ becomes larger and larger, and the value of the potential term is correspondingly lowered, indicating a less evaporation which we know must be the case. When the air becomes saturated, $e_d=e_a$ and the potential becomes $p=(e_s-e_a)$. This expression acquires a very interesting significance with the different values of $e_s$ and $e_a$. For example, suppose that even tho the air be saturated the water is warmer than the air, a condition that frequently occurs in nature. The potential in this case is still finite and positive, which means that vapor will still come off from the water. In fact, the condition is one that explains and accounts for the low layer of fog found over water surfaces on some occasions. If now, we suppose the water is colder than the air, then $e_s-e_a$ becomes negative and the equation gives us a negative evaporation. That is, moisture will condense from the damp air upon the cold water surface. Finally, remembering that we are dealing with saturated air, our whole expression reduces to zero when we assume that $e_s=e_a$. Thus we find that the potential term in this form enables the evaporation equation to meet all the physical demands put upon it, in an entirely comprehensive manner.

The remaining terms of the equation must, of course, be more fully formulated and ultimately evaluated, which is not possible until we have plenty of good observations over a wide range of conditions in which each factor has been accurately measured.

We shall probably have very little difficulty with the barometer term $\frac{1}{B}$ in equation (6). Doubtless it can be written in the form $\frac{B_o}{B}$, where $B$ is the actual and $B_o$ some standard pressure, e. g. 760 millimeters. At any one elevation above sea-level, the ratio $\frac{B_o}{B}$ does not ordinarily differ more than one or two per cent from a mean value. It will, therefore, ordinarily be sufficiently exact to combine this mean pressure term with the general constant of the equation.

[2] The word "potential" is often used, as in the present case, with slight respect to its real technical meaning. Strictly, in the present connection, potential has reference to the state or condition, or relation, of two or more material things, or arrangements, by virtue of which work will be done if the relations are permitted to change spontaneously; or work must be done upon the arrangement in order to change the existing relations otherwise. We have no means of knowing the absolute potential, and, in the present case, all we are concerned with is the difference in potential, by virtue of which the evaporation will be large or small, positive or negative, or zero, according as the difference of potential is large, or small, positive or negative, or zero.

The term $f(e)$ is introduced because without it the equation would affirm that the evaporation and the thermal difference of potential would vary over an indefinite range in a strictly linear relation. This, I think, is quite unlikely. Therefore, some additional function of the thermal factors influencing the rate of evaporation is necessary, or, some exponential relations between these variables must be employed to provide for the probable deviation from a straight-line relation. The expression $f(e)$ is inserted to meet this demand, and will be retained until observations enable us to evaluate it or demonstrate that it is unnecessary.

The wind term $f(v)$ is one the importance of which the writer believes must not be underestimated or subordinated. Dalton assumed that the evaporation increased simply directly as the wind velocity. Professor Bigelow has adopted this view, and, for his first approximation, uses the term $(1+.0175V)$ to represent his Reno observations. In other words the evaporation increases with the wind at the rate of 1.75 per cent per kilometer increase in the hourly velocity of the wind. I believe this simple relation fails to satisfactorily express the real action that takes place. Our knowledge of the effect of wind on a wet-bulb thermometer ought to aid us in forming correct ideas in these matters. Experiment shows that a wet-bulb thermometer in quiescent air cools down by evaporation to a certain definite temperature. If now this air is set in *gentle* motion a considerable further cooling takes place which is increased by increasing the ventilation, but the further cooling by still greater wind velocities is by no means directly proportional to the increase in wind. Shown graphically, the Bigelow wind effect may be represented by the straight line $OB$, fig. 1. I think that the real effect is more nearly represented by a curved line $OM$. It is fully recognized that the line $OB$ is only tentative and rests on very scanty observational data, but I think we must not continue to be content with the simple linear form of the wind influence. I doubt very much if such a term will correctly represent the effect of very light winds, or strong winds on large water surfaces where wave action is strongly developed.

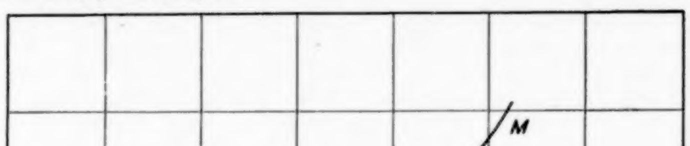



Fig. 1.—Diagrammatic presentation of the wind-effect in evaporation.

The double curvature of the line $OM$ is intended to indicate the real effect we imagine the wind must have. When we observe the evaporation of water in pans, it seems probable the rate, as influenced by the wind can be represented by a line of single curvature. Probably a line of general parabolic character will closely represent the wind effect. But we must not lose sight of the fact that the whole object in view is to formulate an equation that can be applied to open lakes and reservoirs subject to natural conditions. Now, the mass of water, even in a large pan, is so small and so sheltered by the rim that large waves and whitecaps are quite impossible even with very strong winds. On the other hand the wave effect is greatly developed in the open lake where whitecaps are easily formed, which with a number of other concomitant effects must all go to greatly increase the evaporation.



In the absence of observations the line $OM$ is, of course, largely conjectural, but it seems to me a rational conception of the problem indicates that a line of double curvature like $OM$ is required to fully represent the wind effect over large surfaces and large ranges of conditions.

A study of the wave effect has literally not been touched, as yet, and doubtless presents great difficulties. While observations are being confined to pans the line of single curvature like $OP$ is doubtless quite sufficient. This can be written in the equation by the expression $\left(1+av^{\frac{1}{n}}\right)$, where $n$ is 2 or some similar number.

The broad generalizations employed in the development of the new equation do not enable us to specify the exact mathematical form of the several factors controlling evaporation, but the method has this peculiar merit, that in following its guidance we are prevented from getting very far away from a strictly rational general result.

We must defer the further detailed development of the new equation until we have the observational data necessary for that purpose. In the meantime, it will be instructive to consider some of the defects in the other equations.

The Dalton equation has been used by a number of writers in the following form:

$$E=C(e_s-e_d)(1+av). \tag{8}$$

By this equation the evaporation will be zero when $e_s-e_d=0$, that is, when the water surface is at the temperature of the dew-point, which is obviously only true when the air is also at the same temperature. Dalton's equation just misses coming close to the truth by its failure to recognize the part the air temperature takes in controlling evaporation. We have already indicated the probable insufficiency in the wind factor $(1+av)$.

*The Bigelow equations.*—The Bigelow equations, as we have already indicated, introduce variable factors in the form of ratios, and in this respect they are essentially different from the equations employed by others. Professor Bigelow arrived at his results thru a line of reasoning very different from any herein presented. It is desirable, therefore, to follow over his elaborate work and indicate some conclusions that admit of discussion. As his ideas are fully outlined in the several papers already cited, the reader must consult them for such details as are omitted here.

More than one form of equation has been employed by him from time to time, but, for the present, we may take the following form:

$$E=C\frac{e_s}{e_d}\frac{de}{ds}(1+av). \tag{9}$$

The principal modifications in this formula that have been made from time to time have been in the ratio $\frac{e_s}{e_d}$, which is the ratio obtained by dividing the vapor pressure corresponding to the temperature of the water surface by the vapor pressure for the dew-point of the free air. Instead of the latter, Professor Bigelow sometimes substitutes the vapor pressure 1 centimeter above the surface of the water.

We do not need to concern ourselves further than we already have with the wind term $(1+av)$, but will give attention to the factors:

$$C \frac{e_s}{e_d} \frac{de}{ds}.$$

In this expression $\frac{de}{ds}$ is simply the *tabular difference* in the ordinary table of saturated vapor pressures for successive temperatures, and is used here to represent the rate of change of vapor pressure with temperature corresponding to the temperature of the water surface. Professor Bigelow transports this factor from an equation in thermodynamics due to Clayperon, and (by a demonstration which he gives in full at p. 438, Table 23, MONTHLY WEATHER REVIEW, Annual Summary, 1908), he is led to believe that the ratio $\frac{de}{ds}$ is equivalent to the vapor density × constant, and, as such, may be used in the evaporation equation on the ground that it is proportional to the mass of vapor that passes away from the water surface along the tubes of flow.

The Clayperon equation alluded to may be written:

$$\frac{de}{ds} = K \frac{r_2}{T} \frac{1}{(v_1 - v_2)} \qquad (10)$$

in which $K$ is a constant, $r_2$ the latent heat of evaporation of the vapor considered, $T$ its absolute temperature, and $v_1$ and $v_2$ the volumes of the gas and of the liquid which forms the vapor by its complete evaporation.

This equation deals essentially with a definite *static* state of the vapor derived from a given volume of liquid, and has been used by Clausius, and more recently by Ekholm[3], with striking success to formulate the relation between the saturation pressure and the temperature of water vapor. But the phenomenon of evaporation that we are now considering is essentially a dynamic process, not a static condition, and it has not yet been demonstrated that the Clayperon equation is applicable to evaporation data.

Aside from this fact, the ratio is subject to certain sharp limitations that confine its use to a narrow range of temperatures.

The demonstration that

$$\frac{de}{ds} = \frac{K}{v_1 - v_2} \frac{r_2}{T} = \text{density} \times \text{constant}, \qquad (11)$$

rests on the assumption that the ratio $\frac{r_2}{T}$ = constant. This is nearly true only when we limit the application of the equation to a narrow range of temperature. The variation of $\frac{r_2}{T}$ is as great as 5 per cent in the range of temperatures from 10° to 30°C.

This amount of variation rather exceeds the limit of toleration that we should like to allow in a fundamental formula. Moreover, the range 10° to 30°C., is quite too narrow for many important problems. Thus, for instance, we want to be able to handle evaporation from snow at temperatures where the equation would be more than 10 per cent in error. If, therefore, the term is to be retained in a general equation, it will need to be accompanied by the ratio $\frac{r_2}{T}$.

The ratio $\frac{e_s}{e_d}$ or its alternative $\frac{e_s}{e_r}$, is employed by Professor Bigelow, as we understand him, on the basis that it measures, in some way, the vapor pressure *gradient* over or at the water surface. This vapor pressure gradient is one of the forces that causes the vapor to diffuse away from the water, so that the product $\frac{e_s}{e_d} \cdot \frac{de}{ds}$ is of the order of mass multiplied by gradient, and is logically proportional to evaporation. But I think the term $\frac{e_s}{e_d}$ does not have the quality of a gradient at all. In electricity, for example, the flow of current is proportional to *difference* of potential; in hydraulics, it is the *difference* of head; in air masses, the flow is the result of *difference* in barometric pressure, etc. By analogy, therefore, if for no stronger reason, the flow of vapor away from the water surface is better measured by a *difference* of vapor pressures, rather than by a ratio.[4]

There is no part of the Bigelow equation (9), as thus far developed, that enables the expression to take on a zero or negative value as it must do to represent natural evaporation.

At 0° C. $\frac{de}{ds}$ = 0.33 mm. per degree. The value rapidly increases at high temperatures, and is 1.80 mm. at 30° C. This ratio can only become zero at very low temperatures when water vapor no longer exists. The other ratio $\frac{e_s}{e_d}$ must also have a finite positive value. It may sometimes, but not commonly, be less than unity, and it will rarely have a value greater than 4 or 5. Neither of these ratios can have zero or negative values. The power of the equation to represent either zero or negative evaporation resides as yet unrevealed in the $C$-term.

If we apply the expression—

$$E = C \frac{e_s}{e_d} \frac{de}{ds} \qquad (12)$$

to a large body of water, like a lake or reservoir, where the temperature of the water is very nearly a constant from hour to hour and day to day, then the expression $e_s \frac{de}{ds}$ becomes sensibly a constant, and the only term left to provide for variations in evaporation is the ratio $\frac{C}{e_d}$ and the wind.

These broad generalizations indicate, we believe, that the use of such ratios as herein considered in evaporation equations is not likely to be productive of useful results.

Passing from this consideration of evaporation equations in general, we wish to comment briefly concerning the perplexities encountered in the discussion of the Reno and Indio observations, as already outlined in the MONTHLY WEATHER REVIEW.

The discordances are, so far as the writer can see, fundamental and unequivocal. Unfortunately, the original observations are not conveniently available, and the printed material has been built up very extensively by processes of both extrapolation and interpolation. In fact, a large part of it must be regarded as hypothetical, which, it seems, may explain some, if not all, of the trouble.

The chief discordance occurs in the observed amounts of evaporation in large pans floating in the reservoir, and in similar pans more freely exposed 10 feet above ground. The floating pans show very decidedly less evaporation than the exposed pans under what seem to be sensibly the same meteorological conditions.

There are only two possible explanations for this: either (1) some physical element influencing evaporation has not been duly recognized, and therefore not observed or recorded, or (2) the observations are subject to some systematic errors.

There seems to have been no omission whatever to observe regularly at Reno all the meteorological elements that we imagine influence evaporation in any way. We are, therefore, compelled to adopt the view that the actual conditions must differ in some systematic way from those shown by the obser-

[3] Monthly Weather Review. January, 1909, 37:3.

[4] In this connection see below p. 70. Bibliography of evaporation; 1873, Marié-Davy — title.—*C. A. jr.*

vations. The writer believes that a part of the trouble, at least, rests in the estimate of the wind force itself and its effects. The pans exposed in the free air are relatively much more freely exposed, even in light winds, than the pans floating low in a great sheet of water, especially when we bear in mind that the floating pans are extensively surrounded by a floating raft and breakwater system designed with the specific object of checking wind and wave influences. It seems likely, therefore, that the vapor sheet over the floating pans must really have been less disturbed by the wind, and had a greater density than in the case of the pans more freely exposed.

It is hardly worth while to speculate on the details of this problem, or of the several factors of the equation, until we get a sufficient number of exact observations giving us the unequivocal facts upon which we can build. The further evaluation of the terms of the equation herein proposed must, therefore, be deferred to a later paper. It seems necessary, however, to point out at this time, by way of conclusion, that a certain attention is necessary in selecting the proper values of $e_a$ and $e_d$ to use in forming the potential term.

Our judgment on this point must be guided by a careful consideration of the actual mechanics of evaporation which we must consider just briefly at this time.

Evaporation by pure diffusion takes place only in perfectly quiescent air, and we know the process is a very slow one. It is the kind of evaporation that takes place from a pan of water in a large closed room with no appreciable ventilation or convection. An evaporation equation, such as herein proposed, and that seems to meet open-air, windy conditions, must, in all probability, undergo important transformations to fit it to conditions of evaporation by pure diffusion. On the other hand, a pure diffusion equation is likely to be quite unsatisfactory, if applied to evaporation in the moving open air. Conditions favorable to pure diffusion probably never obtain in nature, or so rarely, and for such a short duration, that the amount of evaporation is inconsequential. We must observe, nevertheless, that in very sheltered locations, subject to very little wind, the evaporation may be controlled by the laws of pure diffusion to a very considerable extent, and these must, therefore, come in for a full share of recognition.

Nearly all ordinary evaporation in nature, however, is so dominated by the action of the wind, even when gentle, and by convection generally, that the mechanics of the phenomenon are very complex and very different from one of pure diffusion. Close down to the free water surface we must have a thin layer of air that is heavily charged with water vapor. The Reno observations of humidity one-half inch above the water surface show only a little more vapor than is in the air two or three feet higher. This indicates that the dense vapor sheet is very thin. We know, however, from our knowledge of viscosity and the flow of fluids that in spite of ordinary moderate wind action the thin gaseous sheet immediately next to the water is changed and renewed by the wind only with relative slowness. Vapor molecules that once pass beyond this thin, slow-changing sheet get caught up into the general circulation of the air we call the wind, and are carried away indefinitely.

In the absence of definite data to work upon it would seem that the potential term should be made up from measurement near to, rather than at some distance from the evaporating water surface. As already stated, however, the further solution of these important details must be deferred until some new data are available.

## CHANGES IN THE MONTHLY WEATHER REVIEW.

In order that the readers of the Monthly Weather Review may be prepared for the approaching changes in the scope and character of the Review we print the following order recently issued by the Chief of Bureau.

It appears from the following that those readers particularly interested in climatological statistics should request that the Review be continued to their address; those who are more interested in theoretical and technical discussions of data should request that the Mount Weather Bulletin be sent them in the place of the Review.

U. S. Department of Agriculture,
Weather Bureau,
*Washington, D. C., March 12, 1909.*

Hereafter there will be combined in the Monthly Weather Review all of the State Monthly Climatological Reports, except those from Porto Rico and Hawaii, which with Iowa, will continue as separate publications, but Iowa will also furnish to the Review the same data called for from other sections and it will be included in the Review. The Review will hereafter be a monthly report of the weather and climatology of the country, and there will be excluded from its pages everything technical that is not of a purely climatological nature or a current report of weather conditions.

It will contain no mathematical discussion or formulas. Such mathematical or other technical papers as receive the approval of the Chief of Bureau may be printed in the Mount Weather Bulletin.

The title page will not be changed. The cover will be the same color, but will be of the same weight of paper as that used in the Mount Weather Bulletin. The character of the material to be contained in the Review in generally indicated by exhibit "B," of which everything having a blue pencil mark will be eliminated.[1]

The Review will be printed under the direction of the Chief of Bureau, as indicated on the present title page. No other credit will be given on this page. Each article will be signed by its author, whose name may appear either at the beginning or at the end of the matter, and the Editor's and Assistant Editor's names may be printed on the second page as now.

The issue of the Review will be limited to 5,000. Each section director will be allowed enough copies to supply one copy to each cooperative observer and a few additional copies for distribution only to such as may make a profitable use of the publication. In this connection it must be carefully imprest upon section directors and others that this publication is an expensive one and its distribution must be rigidly limited. When the section directors and libraries and colleges are supplied, the remaining copies will be sent to such of the names on the present mailing list of the Weather Review as may be selected by the board composed of Mr. Williams, and Professors Abbe and Bigelow. Each section director should receive from 10 to 20 extra copies, depending upon the interests in his State to be served by such a report; the number will be determined by the Chief of the Climatological Division.

The report from each section will include the general table and daily precipitation, but the daily maximum and minimum table will be omitted. The Editor of the Review will prepare two charts, at least of the size of the daily weather map; on these charts he will enter such data from cooperative stations as is necessary in the publishing of a monthly temperature chart and a monthly precipitation chart, the temperature chart to include the arrows showing the prevailing direction of the wind. Special care will be exercised in the drawing of these charts so as to recognize the influence due to topography. Where no data is available, the charts will be drawn in accordance with the effect that mountains are known to have upon precipitation and temperature.

The Editors will prepare a complete discussion of the clima-

[1] These blue pencil marks, as put on the Monthly Weather Review for October, 1908, cut out the district reports on p. 326-7; everything on p. 327-345, except "Rivers and Floods," and "Weather of the Month;" the table on p. 356; also Chart IX.

tological features of the entire country for the month. Messrs. Abbe and Abbe, jr., will be the Editors.

Professor Abbe may have a short chapter each month under the caption of "Notes by the Editor," in which he will make a review of the progress of meteorological science or write about incidents thereto. An occasional article that deals with the climatology of the United States or of some portion of the world may also be included.

Each section director will report any items of special meteorological interest that may be observed in his section during the month, but all such data as giving the dates of the numerous thunderstorms and frosts and hails will be omitted unless they have a peculiar significance to the weather of the month. The Editor in writing his review of the month may refer to these if he thinks they are important.

The country will be subdivided into twelve natural climatic divisions that shall be consistent with the various watersheds, and the data will be grouped and published at this office in accordance with these new divisions.

The new publication will begin as soon as necessary arrangements can be effected. [Probably with the number for July, 1909.] * * *

Respectfully,

(Signed) WILLIS L. MOORE,
*Chief U. S. Weather Bureau.*

On April 1, 1909, "the Review Room and the work pertaining thereto" was transferred to the Climatological Division, and shortly afterward the following order was issued:

U. S. DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU,
*Washington, D. C., April 9, 1909.*

Professors Abbe and Bigelow may each write reviews of, comments on, or criticisms of meteorological papers, researches or events, and publish them in the Review over his own signature. Mr. Abbe, jr., will, under the caption "Editor's Notes," and with appropriate subcaptions, briefly note the development and progress of meteorological science thruout the world, so that the Review may still mark, step by step, the development of the science without becoming a meteorological journal and without publishing extensively the details of meteorological papers.

Respectfully,

(Signed) WILLIS L. MOORE,
*Chief U. S. Weather Bureau.*

## WEATHER WORDS IN ALL LANGUAGES.

The historical development of the study of meteorology has a very interesting side when we turn to the terms that are used by various nations. The comparison of these terms is not merely a study in comparative philology, but it throws light upon the poetical and philosophical ideas current among the respective nations. Moreover, as weather, storms, rain, and wind are common thruout the world, and every nation must have words for these simple elementary ideas, we should by means of the similarity of terms be able to infer something as to the intercourse of nations with each other, and the influence of one nation on others. A friend in New York has lately promised us a complete collection of meteorologic terms in use among the natives of various tribes that occupy nearly all the islands of the Pacific Ocean, and it is not impossible that this may throw light upon the methods by which those tribes have been dispersed thruout this aqueous half of the globe. Gov. John P. Finley, of Zamboanga, P. I. (who is also Major in the 28th Infantry, U. S. A., and was well known twenty years ago as an officer of the weather service actively interested in the study of tornadoes), has kindly furnished us with the following extensive list of names of certain meteorological terms used in the Philippines by English, Spanish, Maguindanao Moro, Sulu Moro, and Malay. The Maguindanao Moro terms are given in both English and Arabic characters, which latter we omit. We understand that the Arabic characters are used quite extensively in the Philippines, and it seems to us not unlikely that traces of old Arab terms may still survive in the extreme East. We have often stated that the term *euroclydon* which appears in Acts, Chapter XXVII, verse 14, as a Greek word, is simply a transliteration to suit the Greek taste for euphony of the Phoenician or Hebrew words *eulos krudon*, a strong wind, which itself must have been closely allied to some Arabic term. As the Phoenicians were great sailors and the Arabs equally extensive traders and travelers, we may not unreasonably expect to find other Phoenician and Arabic words transmuted into modern popular usage. To those who take an interest in philology and etymology we commend the history of words relating to the weather as a subject that is likely to throw light upon the earliest phases in the history and migrations of nations.—*C. A.*

*Meteorological terms used in the Philippines, compiled by Maj. J. P. Finley.*

| English. | Maguindanao (Moro). | Sulu (Moro). | Spanish. | Malay. |
|---|---|---|---|---|
| White clouds | Gabun a maputi | Andum puti | Nubes blancas | âwan puti. |
| Dark clouds | Gabun a maytûm or (Rûndûng) | Gabun | Nubes obscuras | âwan itam. |
| High clouds | Gabun a mapuːu | Awan mata'as | Nubes elevadas | âwan tinggi. |
| Low clouds | Gabun a mababa | Awan hababa' | Nubes bajas | âwan randah or rendah. |
| Clouds | Gabun | Awan | Nubes | Awan. |
| Fog | Lûkûp | Gabun | Niebla | Kabut. |
| Rain | Uran | Ulan | Lluvia | Hujan. |
| Heat | Kayaw | Pasu | Calor | Panas. |
| Cold | Katinggaw | Haggut | Frio | Sejuk. |
| Rainbow | Bulutu or Tupung. | Inàk | Arco iris | Plangi. |
| Storm | Ribut or Subusubu. | Hunus or Unbak tawpan. | Tormenta | Ribut. |
| Thunder | Ruggung | Dawug-dug or Daug-dug. | Trueno | Guroh. |
| Lightning | Kilat | Kilat | Relampago | Kilat. |
| Wind | Undu' | Hangin | Viento | Angin. |
| Snow or hail | Uran-watu | Ulan batu | Nieve ó granizo | Thalj (Ar.). |
| Ice | Ig-a-watu | Tubig-batu | Hielo | Ayar baku. |
| Moisture | Magbasa or Musa | Basa' | Humedad | Lengas. |
| Current | Margûs Ig | Sûg | Corriente | Arus. |
| Kite | Layang-layang | Taguri | Cometa | Layang-layang. |
| Waterspout | Subu-subu | Bûhawi | Manga marina | Puting blion. |
| Whirlwind | Ripurus | Ayimpus or Aimpus. | Remolino | Angin puting blioug. |
| Sunlight | Sigay | Sawa | Luz del Sol | Trang. |
| Darkness | Kalibutûng | Lindom | Oscuridad | Glap. |
| Moon | Ulan-ulan | Bulan | Luna | Bulan. |
| Sun | Snang | Suga | Sol | Mata hari. |
| Star | Bitun | Bit'un | Estrella | Bintang. |
| Weather (day) | Gay | Adlaw | Tiempo | Musim. |

## WINTER ARIDITY INDOORS.

By Prof. M. S. W. JEFFERSON, Ypsilanti, Mich.

[Reprinted from Journal of Geography, Vol. I, No. 10, December, 1902.]

The very interesting paper by Professor Ward in the September Journal of Geography[1] suggests arithmetical treatment to show the actual quantities of water demanded in connection with a heating and ventilating plant to preserve a healthful humidity within doors in winter.

On the average of the twenty-one days of Professor Ward's observations an outside temperature of 36° F. was accompanied by a relative humidity of 71 per cent. There were present then in each cubic foot of air 1.77 grains of water vapor. This was warmed within the house to a temperature of 69° and then showed a relative humidity of 30 per cent. Corresponding to these figures is a water vapor content of 2.32 grains per cubic foot, showing an increase in the absolute amount of water present of 0.55 grain per cubic foot, which must be credited to the water pans used in connection with the heating apparatus.

To obtain what we might call a healthful humidity, of say 70 per cent at 70° F., 5.59 grains of water are needed to the cubic foot. There was a deficit of water vapor then in the room examined to the amount of 3.82 grains per cubic foot.

[1] See Monthly Weather Review, September, 1908, 36:281.

It appears, therefore, that the water pans supplied little more than one-seventh as much water as was needed for proper humidification, if the standard set of 70° F. and 70 per cent humidity be a proper one.

Knowing the quantity of air supplied per minute by a heating plant, it is a simple matter to estimate the amount of water that should be evaporated and added to air of given outside temperatures and humidities.

Clearly we are best off in winter in this respect when the outside air is saturated. Suppose an outdoor temperature of 40°. At saturation there are present 2.85 grains of water to the cubic foot. If a heater raises this air to 70° without adding to its water content, it will become drier as failing to increase its water along with its temperature. In other words, to maintain saturation at 70° F. needs 7.98 grains of water to the cubic foot, and having still but 2.85 it is said to have only $2.85 \div 7.98$, or 36 per cent [of the amount of] water [needed] to saturate it. Its relative humidity, therefore, is 36 per cent. For the 70 per cent humidity assumed as a desirable standard, we need $0.70 \times 7.98 = 5.59$ grains of water. The heating apparatus should therefore add 2.74 grains of water at the same time as it raises the temperature in order to produce the desired humidity. This additional 2.74 grains is a minimum quantity, however, since we have assumed the favorable case of saturated outer air. Had the outer air contained the average 69 per cent of Professor Ward's table, the water vapor present would have been only $0.69 \times 2.85$ or 1.97 grains per cubic foot and the additional water needed to obtain the desired humidity would be 3.62 grains. Table A gives the relative humidities that would result from raising to 70° F. without adding water, outer air at various temperatures, from 0° to 50° and relative humidities from 60 to 100 per cent.

TABLE A.—*Showing inside humidities corresponding to certain outside humidity.*

| Outside humidity. | 60 per cent. | 80 per cent. | 100 per cent. |
|---|---|---|---|
| Outside temperatures. °F. | In-ide humidity. (Per cent.) | | |
| 0 | 4 | 5 | 6 |
| 10 | 6 | 8 | 10 |
| 20 | 9 | 12 | 16 |
| 30 | 14 | 19 | 24 |
| 40 | 21 | 29 | 36 |
| 50 | 31 | 41 | 51 |

The number of grains that should be added in each case to bring the humidity up to 70 per cent when air has been raised to 70° is given in similar form in Table B.

TABLE B.—*Amount of water required to bring inside humidity to 70 per cent when the temperature is raised to 70° F.*

| Outside humidity. | 60 per cent. | 80 per cent. | 100 per cent. |
|---|---|---|---|
| Outside temperatures. °F. | Grains of water. (Cubic foot.) | | |
| 0 | 5.30 | 5.21 | 5.11 |
| 10 | 5.12 | 4.97 | 4.81 |
| 20 | 4.85 | 4.60 | 4.35 |
| 30 | 4.43 | 4.04 | 3.65 |
| 40 | 3.88 | 3.31 | 2.74 |
| 50 | 3.14 | 2.33 | 1,51 |

This table is a somewhat precise expression of the fact that the drier and colder the air outside, the more intense and unwholesome the indoor aridity that results from heating air without humidifying it, and the greater the demand on any humidifying arrangement for water to compensate the effect of raised temperature. According to Chamber's Encyclopedia, "Ventilation" requires a supply of 20 to 30 cubic feet of air per minute per individual. Let us say 25 cubic feet per minute or 36,000 per day of twenty-four hours. To find the daily need of water corresponding to that air supply per individual, we multiply the grains per cubic foot of Table B by 36,000, and divide by 14,600, the number of grains to a quart, giving us Table C with quarts of water per day per individual needed to correct the aridity of air that has been raised to 70° from the outside conditions tabulated.

TABLE C.—*Daily amount of water, per individual, required to correct the aridity of air raised to 70° F.*

| Outside humidity. | 60 per cent. | 80 per cent. | 100 per cent. |
|---|---|---|---|
| Outside temperatures. °F. | Quarts per day. | | |
| 0 | 13.7 | 12.8 | 12.6 |
| 10 | 12.6 | 12.2 | 11.9 |
| 20 | 12.0 | 11.3 | 10.7 |
| 30 | 10.9 | 10.0 | 9.0 |
| 40 | 9.6 | 8.2 | 6.8 |
| 50 | 7.7 | 5.8 | 3.7 |

From Table C it appears that under the average conditions of Professor Ward's twenty-one days, about 2 gallons of water per individual should be evaporated to humidify his daily supply of air. A family of 5 persons would need 10 gallons of water evaporated daily for the same purpose, and a schoolhouse 200 gallons of water daily per 100 pupils. If the air supply assumed at 25 cubic feet per minute be not an actual quantity, it is simple to assign the proper proportionate value for any known rate of air supply. We might cut down a school supply by reducing the hours allowed for daily use from 24 to 9, corresponding to a drop from 200 gallons per 100 pupils to 75 gallons daily. On the other hand, Professor Ward's instructive observations were far from approaching the extremes met any winter in American houses, as his coldest outside temperature mentioned is 23° and least outside humidity 51 per cent. From Table A we learn that zero temperatures with a humidity of 60 per cent means an inside humidity of 4 per cent if the air is raised to 70°F. without additional water. Even adding the maximum amount supplied by Professor Ward's water pans in any day (November 11), 1.18 grains, we yet have a relative humidity of only 18.4 per cent. If it is true that a cold spell makes it hard to keep up to 70°, it is also true that we suffer in the defect of temperature, and also the outer air may commonly have a humidity far below 60 per cent. W. M. Davis says (Meteorology, p. 145) we may have as low as 30 per cent in our winters. Ultra-desert conditions undoubtedly occur within doors every winter.

## HONESTY THE BEST POLICY.

In his address on earthquake forecasts[1] before the American Association of Geographers at Baltimore, January 1, 1909, Dr. G. K. Gilbert touches on a question that has been discust before in these columns, viz, the disadvantages in connection with the attempted concealment of dangers from natural phenomena. His remarks apply equally well to meteorological as to earthquake phenomena.

> The proposition that it should be the policy of the inhabitants of an earthquake district to recognize the danger and make provision for it appears self-evident, but I regret to say that its soundness is not universally recognized in California.
>
> * * * * * * *
>
> This policy of assumed indifference, which is probably not shared by any other earthquake district in the world, has continued to the present time and is accompanied by a policy of concealment. It is feared that if the ground of California has a reputation for instability, the flow of immigration will be checked, capital will go elsewhere, and business activity will be impaired. Under the influence of this fear, a scientific report on the earthquake of 1868 was suppressed. When the organization of the Seismological Society was under consideration, there were business men who discouraged the idea, because it would give undesirable publicity to the subject of earthquakes. Pains are taken to speak of the disaster of 1906 as a conflagration, and so far as possible the fact is ignored that the conflagration was caused, and its extinguishment prevented, by injuries due to the earthquake. During the period of aftershocks, it was the common practise of the San Francisco dailies to publish telegraphic accounts of small tremors perceived in the eastern part of the United States, but omit mention of stronger shocks in the city

[1] See Science, 1909, 29 (N. S.): 135-6.

itself; and I was soberly informed by a resident of the city that the greater number of the shocks at that time were occasioned by explosions of dynamite in the neighborhood. The desire to ignore the earthquake danger has not altogether prevented the legitimate influence of the catastrophe on building regulations and building practises, but there can be little question that it has encouraged unwise construction, not only in San Francisco but in other parts of the malloseismic district.

The policy of concealment is vain, because it does not conceal. It reflects a standard of commercial morality which is being rapidly superseded, for the successful salesman to-day is he who represents his goods fairly and frankly. It is unprofitable, because it interferes with measures of protection against a danger which is real and important.

## IS THIS ONE NATURAL METHOD OF MAKING SNOW?

Mr. W. W. Neifert, Local Forecaster at Hartford, Conn., recently sent the Editor the following clipping from the New England Palladium for February 6, 1810.

Springfield, Mass.
January 15, 1810.

A very singular appearance was exhibited in this town on Friday last. The Thermometor standing at 0, and two degrees above, with the wind very high at North West. The river furnished an appearance of a heavy fog passing rapidly down it. On an appearance so extraordinary examination was made, and it was found that the wind took the small particles of water and carried them up into the atmosphere, where they immediately congealed into fine snow; they arose some as much as 40 feet above the surface of the water. Its commencement was about meridian, and continued through the day, but most conspicuous at 2 P. M. Several very aged people living in this vicinity do not remember ever seeing the like appearance.

## WEATHER BUREAU MEN AS EDUCATORS.

J. W. Bauer, Section Director, Columbia, S. C., reports that the faculty and trustees of the University of South Carolina have just added an elective course in "Elementary and Practical Meteorology" to the curriculum of that institution. The course will begin about February 16, and will consist of 15 weekly lectures by the official in charge of the local office. Waldo's Elementary Meteorology will be used as a text. The class is expected to number about 15 students.

M. E. Blystone, Local Forecaster, Providence, R. I., reports that on January 4 he addrest the Men's Club of the Congregational Church, Seekonk, Mass., on "Weather Forecasts;" repeated this address on the 28th before the Men's Club of St. James Episcopal Church, Providence.

W. D. Fuller, Observer, reports that classes from the Pasadena and South Pasadena High Schools visited the Los Angeles, Cal., office on February 17 and 18; and from Throop Polytechnic Institute on the 23d. These classes visit the office regularly every year.

Eric R. Miller, Local Forecaster, Madison, Wis., reports that on February 23 he began a course in climatology at the University of Wisconsin. The class meets three times weekly for lectures, recitations, and practical exercises, using Hann-Ward's Climatology as a text. The enrolment is 1 student from the School of Agriculture, 2 from Engineering, 3 from Letters and Science, and 6 from Commerce.

E. H. Nimmo, Observer, Sandusky, Ohio, reports that a class from the Sandusky High School visited the local office on February 18, 1909.

G. H. Noyes, Local Forecaster, Lexington, Ky., addrest the Men's Club of the Second Presbyterian Church of that city on February 1, 1909. His subject was "The daily workings of the Weather Bureau."

H. W. Richardson, Local Forecaster, Duluth, Minn., reports that on February 10 he gave an illustrated talk before the Park Point Improvement Club on "The Weather Bureau."

J. Warren Smith, Section Director, Columbus, Ohio, reports that classes from the Central High School visited the local office on February 10 and 11.

Wilford M. Wilson, Section Director, Ithaca, N. Y., reports that during February he gave illustrated lectures on topics pertaining to the work of the Weather Bureau before the Cornell Agricultural Association, the Political Study Club, Short Course Students' Association, Forest City Grange, Town and Gown Club, Ithaca Business Men's Association; also two lectures at the College of Agriculture during Farmers' Week.

M. L. Fuller, Observer, Canton, N. Y., reports that on January 26, he delivered a lecture on "The practical value of the Weather Bureau" before the "Farmers' Week" assemblage at Canton, N. Y. After the lecture a considerable portion of the audience visited and inspected the local office in the Carnegie Science Building, St. Lawrence University.

## INFLUENCE OF MOUNTAINS AND COASTS ON STORMS.

By D. T. Smith, M. D. Dated Louisville, Ky., March 1, 1909.

In the December number of the Monthly Weather Review the Editor remarks that "It is very desirable that some one should explain in detail the mechanism by which a given range of mountains or the coast of a continent deflects the path of a hurricane center. The east-west ranges in the West Indian Islands and the northeast-southwest Appalachian Range appear to have appreciable influence on some storms, but not on others."

For more than twenty years the writer has been trying to attain the result suggested by the development of a theory that has grown with the development of facts.

The Monthly Weather Review of June, 1906, 34:280, published this theory of mine which is that cyclones and hurricanes, which seem to be nothing else than cyclones moving under the more favorable conditions of tropical seas, derive their movement of translation from the necessity of the coincidence of their center of gravity and their axis of rotation.

At the request of Dr. Hugh Robert Mill, editor of Symons's Meteorological Magazine, this theory was set forth more elaborately in the issue of that journal for May, 1908.

The contention is that the upper constant currents blowing toward the west, in the Tropics, then circling around to become the constant westerlies of the temperate and polar regions, are continually beheading the cyclone, thereby creating a partial vacuum, and that the pressure of the surrounding air into this is the chief source of all cyclonic energy.

The cyclone measurably yields to these currents and leans over in the direction of their motion. The air rushing in from all sides fills up the space in front under the leaning body faster than the rear can be added to, and this shifts the center of gravity forward. Since the mass of the cyclone or hurricane is rotating, the axis must move forward continuously to correspond with the center of gravity, and thus the cyclone is kept constantly advancing. If a mountain chain lies across the cyclone path it will prevent the increase of diameter in front, and thus hold the center of gravity and axis, for a time, stationary. Or it may happen that the mountain chain will hold back the inrush of air in front until that already present is sucked up into the cyclone, thus moving back the center of gravity, and as a result the center of the cyclone will actually recede for a time and has been known to do so.

After a time the cyclone begins to be added to in front above the level of the mountains. This moves the center of gravity forward and the cyclone proceeds to cross the range.

A mountain range running in the direction of travel of a cyclone would deflect the path of a cyclone away from itself in proportion as the diameter of the cyclone's base was interfered with.

If the level of outflow in a cyclone should happen to be unusually high, it would not need to halt at an ordinary mountain chain, and it would be less affected by such a chain parallel with its path.

Continents affect cyclones variously, or rather the frictional resistance of continents must meet a variety of conditions. Tropical cyclones (and I much doubt if there are any other

kind) beaten back by the trade winds would probably never get poleward of the Tropics if it were not for the arrest of these winds by continental friction. This friction often becomes effective some distance to the eastward over the ocean by damming back the trades. It thus happens that cyclones are often carried poleward by the antitrades [prevailing westerlies?], and started on their eastward journey while still some distance out at sea, as on the coast of Florida, Australia, etc.

## BAROMETRIC PRESSURE AND EARTH PULSATION.[1]

By N. Shimono, Japan.

According to Professor Omori pulsation of the earth is due to changes in the pressure upon the earth's crust and these are mostly caused by barometric depressions, or by changes in sea-level when the latter occurs, but not to the wind itself. The following is the result of our investigations into the relation between barometric depressions and the earth's pulsation as observed in the vicinity of Osaka. On the morning of the 4th of August, 1908, a barometric depression made its appearance at sea far to the south of Ishigakijima, and it past between Okinawajima and Emi-Oshima at 6 a. m. of the 6th with the barometer showing a pressure of 735 millimeters. The center of the depression then moved northeastward and approached the southern coast of Kii at 6 a. m. of the 7th. Thence it moved toward Nagoya and past thru Honshu entering the Japan Sea. According to the Omori seismograph at Osaka Observatory, the pulsatory oscillations became more frequent as the depression approached and were recorded in in the greatest numbers on the evening of the 7th, the amplitude of the east-west component being 0.06 millimeter, and that of the south-north component 0.07 millimeter. As the depression past away northeastward the pulsatory oscillations gradually decreased.

The barometric depression of July 22-28, 1906, which past over the southern and southeastern coasts of Japan, the depression of December 20-24, 1907, which past eastward over the Japan Sea, and the barometric depression of August 22-28, 1908, which moved from the eastern China Sea across the Yellow Sea and then toward Siberia, not only confirm the above statement but also prove that when there is a strong barometric gradient the number of pulsatory oscillations of the earth's crust is greatly increased.

We next made some study of the relation between the wind and the pulsatory oscillations, but we could hardly find any such relation.

## RESEARCHES ON THE SOLAR CONSTANT AND THE TEMPERATURE OF THE SUN.

By Dr. J. SCHEINER, Potsdam, Berlin.

[Extract from Monthly Notices, Royal Astronomical Society, 1908, 68:662.]

The measurements of the sun's radiation were made with the Angström electric compensation pyrheliometer, to which I had given a modified exterior form and a parallactic motion with clockwork. On eleven days in June and July, 1903, I made a long series of observations on the summit of the Görner Grat, Canton Wallis, Switzerland, from which I could derive the radiation of the sun outside our atmosphere. This part of the problem is the most difficult one, and according to my view it can not be solved from measurements of the solar radiation alone. From such observations a portion only of the real solar constant can be obtained, because only that portion of the loss by absorption in our atmosphere can be calculated which is based upon the *continuous* increase of absorption with growing thickness of the atmosphere traversed by the radiation. With carbon dioxide and water vapor there exists a nearly sudden absorption in the highest thin layers of the atmosphere, which must be treated as a constant to be added to the radiation-curves. Therefore this latter result is not the solar constant as generally supposed, and I have chosen for it the term "Strahlungs-konstante" or "constant of radiation."

From my observations on the Görner Grat it amounts to 1.95-2.02 gram-calories. The remaining constant, which must be added to it in order to obtain the solar constant, can be found only from experimental researches in the laboratory. To this part of the problem I have devoted much labor in measuring the absorption of carbon dioxide and superheated water vapor with varying depth of layer.

This very complicated research can not be described in a short abstract, and I must therefore refer the reader to the original paper. The result is that to reduce the "constant of radiation" to the solar constant there must be added for carbon dioxide 1 per cent, for water vapor 7 per cent, and for the ultraviolet absorption 1.5 per cent, whence the solar constant for the unit of distance is found to be 2.22-2.29 gram-calories, with a probable error of 2 per cent.

## THE BLANKET EFFECT OF CLOUDS.

By Dr. W. W. COBLENTZ, Ph. D. Dated Washington, D. C., February 12, 1909.

In the various discussions of meteorological and geological phenomena, the "greenhouse" and "blanket" effect of clouds in conserving terrestrial temperature seems to have been pushed to the limit without considering the functions that clouds can perform.

First of all, water is the most opaque substance known for infra-red radiation, but it is very transparent for light waves. It belongs to the class of substances known as "insulators" or "transparent media," in which the reflecting power is a function of only the refractive index, the absorption coefficient (altho high for water as compared with other transparent media) being still too low to affect the reflecting power. This means that since the refractive index of water is low, the reflecting power is low. Indeed water is unique in this respect, for it has no marked bands of metallic reflection such as obtain in quartz, glass, and various other minerals. The reflecting power of a plane surface of water is less than 8 per cent thruout the spectrum to $20\mu$, and in the regions where there are no absorption bands the reflecting power is much less, even as low as 2 per cent.

Let us now consider what must be the behavior of water in the form of clouds. The albedo of clouds for sunlight is more than 60 per cent. The value of the refractive index shows that the reflecting power can not be much above 2 per cent, and the high value of 60 per cent must occur as a result of scattering at the surface of the water globule and of internal reflection.

In the infra-red there can be but little internal reflection due to the great opacity of the water globule for heat waves. Hence the reflecting power must remain low, and of the same magnitude as that of a plane surface, viz, from 2 to 5 per cent. If water had bands of strong selective reflection in the infra-red the albedo of clouds might be higher than the above estimates.

The "blanket" effects of clouds must therefore be due principally to their high emissivity (for those radiations emitted by the earth) hence to their high efficiency as a heat radiator. By definition the Kirchhoff radiator (so-called "black body") is one in which the reflecting power is *nil* and which is perfectly opaque. Water fulfills this first condition to within 2 to 5 per cent (depending upon the wave-length) and the second condition to such an extent that a layer 1 cm. thick absorbs completely all radiation of wave-length greater than $1.5\mu$ in the infra-red. In the region of $8\mu$, where lies the earth's maximum emission, less than 1 mm. thickness of water is required to produce complete opacity. The "blanket"

[1] Abstract in English, reprinted from Journal Meteorological Society, Japan, September, 1908, 27th year, No. 9, p. 25-6.

effect of clouds is therefore to be explained by their high emissivity in the infra-red, whereby the radiant energy received from the earth is almost perfectly reëmitted.

## MEAN ANNUAL TEMPERATURES FOR MEXICO AND CENTRAL AMERICA.

In the MONTHLY WEATHER REVIEW for April, 1908, we had the pleasure of publishing a very complete and careful table of mean annual temperatures for a number of stations in the various States of Mexico. The author of that table, Prof. Philip P. Calvert, has recently charted the data there presented and published a map showing the "Actual distribution of mean annual temperatures" in Mexico and Central America.[1]

This map extends from the latitude of Little Rock, Ark., to Mariato Point, Panama, and presents the temperature conditions of the region by means of a scale of colors which divide the country into six zones. Zone I includes that district probably having an actual mean annual temperature of more than 30° C., and the successive zones embrace differences of 5° C. up to zone V, whose mean annual temperatures are 15° to 10° C. and zone VI, whose mean annual temperatures are below 10° C. With regard to the character of zone I Professor Calvert says: "It should be added that the existence of zone I, with a mean annual temperature of more than 30° C., rests solely on the authority of the map of Senties and Reyes, that it is doubted by Señor Pastrana, and that I have not succeeded in finding any published records of temperature observations in the valley of the Rio de las Balsas for a period of more than two months." The colorings of the zones are not confined to the mainland but embrace a portion of the Bahamas, the coast of Cuba, and the whole of Jamaica. In bounding these zones the topography, as given on the latest and best maps, has been taken into account; but beyond a few general hachures, there is no attempt to represent on this map the topographic relief of the region, and no scale is given. The size of the map is 19.8 by 25.8 centimeters.

The sources of the data of this map are sufficiently indicated by the references given in the article in the April, 1908, REVIEW.—*C. A., jr.*

## RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Librarian.

**The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers or other communications bearing on meteorology or cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled; it shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau. Unsigned articles are indicated by a ——**

*American geographical society. Bulletin. New York. v. 41. Feb., 1909.*
**Ward, Robert DeC.** Pneumonia and weather. p. 104-105.
*American journal of science. New Haven. 4th ser. v. 27. March, 1909.*
**Dike, P. H.** Recent observations in atmospheric electricity. p. 197-209.
*Engineering news. New York. v. 61. Feb. 11, 1909.*
**Eby, J. H.** Still more about forests, snow, and stream flow. p. 162.
*London, Edinburgh, and Dublin philosophical magazine. London. 6 series. v. 17. Feb., 1909.*
**Wright, C. S.** On variations in the conductivity of air inclosed in metallic receivers. p. 295-318.
*Science. New York. N. S. v. 29. Feb. 19, 1909.*
**Jochelson, Waldemar.** The Riabouschinsky expedition under the auspices of the Imperial Russian geographical society. p. 303-305.

[1] As "Neuroptera, Map 1," in the volume "Neuroptera" of Biologia Centrali-Americani, edited by F. D. Godman. London, 1901-1908. 4to.; also as plate 26 in Proc. Acad. Nat. Sci., Philadelphia, October, 1908, p. 460-491. This article contains some discussion of the relations between temperature, rainfall, and insect life in Mexico.

*Scientific American. New York. v. 100. Feb. 27, 1909.*
**Fergusson, S. P.** The exploration of the upper air by means of ballons sondes. p. 169-170.
*Scientific American supplement. New York. v. 67. March 13, 1909.*
**Gilbert, G. K.** Earthquake forecasts.—III. Future possibilities. p. 174-175.
*Symons's meteorological magazine. London. v. 44. Feb. 1908.*
**Mossman, R. C.** The cold period of May in Arctic and Antarctic regions, with special reference to 1903. p. 1-6.
*Archives des sciences physiques et naturelles. Genève. Tome 22. 15, janvary, 1909.*
**Mercanton, Paul L.** L'hygromètre à rameau de sapin. p. 93. [Abstract].
*France. Académie des sciences. Comptes rendus. Paris. Tome 148. 1908.*
**Lacroix, A.** Résumé de quelques observations de M. A. Ricci sur le tremblement de terre de Sicile et de Calabre de 28 décembre 1908. (25 jan.) p. 207-209.
*Géographie. Paris. Tome 18. 1908.*
**Laloy, L.** Le climat des îles de la Méditerranée. (15 octobre). p. 258-259. [Abstract of paper by Grand Duke Ludwig Salvator.].
**Baillaud, B.** Les observatoires de montagne. (15 décembre) p. 361-374.
*Société belge d'astronomie. Bulletin. Bruxelles. 13 année. Dec., 1908.*
**Arctowski, Henryk.** Les variations des climats. p. 398-401.
**Nodan, A.** L'origine solaire des cyclones et des tempêtes. p. 407-410.
*Société Ramond. Bulletin. Toulouse. 3 sér. 43 année. Juil.-Sept., 1908.*
**Marsan, François.** Météorologie ancienne du midi Pyrénéen. p. 153-155.
**Bouget, —., & Marchand, [E].** L'influence des couches inférieures de nuages sur la distribution des végétaux en altitude dans les Pyrénées. p. 221-222.
*Akademie der Wissenschaften. Sitzungsberichte. Wien. Bd. 116. Jan., 1907.*
**Pernter, J. M.** Zur Theorie der "schönsten der Haloerscheinungen." p. 17-48.)
*Meteorologische Zeitschrift. Braunschweig. Band 26. Jan., 1909.*
**Kassner, C.** Bericht über die elfte allgemeine Versammlung und Feier des 25 jährigen Bestehens des Deutschen Meteorologischen Gesellschaft zu Hamburg am 28. bis 30. September 1908. p. 2-10.
**Kahler, Karl.** Registrierungen des luftelektrischen Potentialgefälles an nahe benachbarten Stationem. p. 10-17.
**Jensen, Chr[istian].** Die gegenwärtigen Probleme und Aufgaben, welche mit dem Studium der atmosphärischen Polarisation verknüpft sind. p. 18-19. [Abstract.]
**Köppen, W.** Die Wechselwirkung zwischen der maritimen und der Landmeteorologie in deren Entwickelung. p. 19-21. [Abstract.]
**Erk, [Fritz].** Technische Erfahrungen und wissenschaftliche Resultate von der Hochstation Zugspitze. p. 21-22. [Abstract.]
**Rotch, A. L.** Die warme Schicht der Atmosphäre oberhalb 12km. in Amerika. p. 22-23. [Abstract.]
**Wegener, Alfred.** Vorläufiger Bericht über die Drachen- und Ballonaufstiege der Danmark-Expedition nach Nordostgrönland. p. 23-24. [Refers to first photographs of mirage. Abstract.]
**Schmauss, A.** Gleichzeitige Temperaturen auf der Zugspitze und in der gleichen Seehöhe der freien Atmosphäre über München. p. 24. [Abstract.]
**Coym, A[rthur].** Ueber absolute Strahlungsmessungen im Freiballon. p. 24-25. [Abstract.]
**Schreiber, P[aul].** Ueber die Verwendung der Thermodynamik bei der Diskussion von Ballonbeobachtungen. p. 25-27. [Abstract.]
**Börnstein, R[ichard].** Der öffentliche Wetterdienst, namentlich im norddeutschen Gebiet. p. 27-28. [Abstract.]
**Köppen, W.** Ueber die Guilbertschen Regeln für die Wetterprognose. p. 29-30.
**Erk, [Fritz].** Zur Methodik des Unterrichtes in der Meteorologie. p. 31-32.
**Möller, Max.** Die Luftwelle hoher Schichten. p. 33.
**Maurer, J[ulius].** Gebirgswinter und Lawinenfall. p. 33-36.
**Krebs, Wilhelm.** Seltene Polarisation des Himmelslichtes. p. 37-38.
**Taudin Chabot, J. J.** Zur Meteorologie der Kohlengrube. Unerkannte Probleme. p. 38-39.
——Ballonfahrt von ausserordentlicher Geschwindigkeit. p. 40-41. [Speed of 150 km. an hour attained in balloon voyage].
——Ernest Esclangon über die Dämmerungslichter. p. 44-45.
*Prometheus. Berlin. 20. Jahrgang. 3 Feb., 1909.*
**Baumgart, Ludwig.** Gott Brahams Blitzableiter. p. 277-279. [Protection from lightning afforded by banyan trees.]
*Weltall. Berlin. 9. Jahrg. Februar 1909.*
**Wetekamp, W.** Eigentümlicher Sonnenuntergang am Wattenmeere. p. 141-142.
**Strömer, Carl.** Neuere norwegische Untersuchungen über die Natur der Polarlichter. p. 145-153. [Illustrated. Includes chart showing geographic distribution of the aurora borealis.]

*Wetter. Berlin. 26. Jahrgang. Jan., 1908.*
**Mylius, G.** Ueber Böen und Gewitter. p. 1-10.
**Lindemann, —.** Die grössten Tagesmengen des Niederschlages im Königreich Sachsen von 1866 bis 1905. p. 10-13.
**Joester, Karl.** Die Föhnerscheinungen im Riesengebirge. p. 14-17.
**Freyde, Otto.** Der Wetterdienst in Winter. p. 21-24.
*Woche. Berlin. 13. Feb., 1909.*
**Hennig, R.** Die jüngste Ueberschwemmungskatastrophie. 266-267; 272-275. [Illustrated].
*Zeitschrift für Luftschiffahrt. Berlin. 13. Jahrgang. 10 Feb. 1909.*
**Wendt, J.** Die Drachenstation der Deutschen Seewarte 1907 und 1908.

## RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Librarian.

**The following have been selected from among the titles of books recently received, as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies. Most of them can be lent for a limited time to officials and employees who make application for them. Anonymous publications are indicated by a ——.**

**Baden. Zentralbureau für Meteorologie und Hydrographie.**
Niederschlagsbeobachtungen . . . Jahrgang 1908. Karlsruhe. 1909.

**Batavia. K. magnetisch en meteorologisch Observatorium.**
Observations. . . v. 29, 1906. Batavia. 1908. xxxvii, 162 p. f°.
Regenwaarnemingen in Nederlandsch Indie 1907. Batavia. 1908. 392, 190 p. 4°.

**Bauer, George.**
Ein Beitrag zur Förderung des Unterrichts in der Meteorologie. Greifswald. 1908. 42 p. 8°. (Beilage zum Jahrbericht des Gymnasiums und der Realschule zu Greifswald. Ostern 1908.)

**Bechtle, A.**
Klima, Boden und Obstbau. Frankfurt a. Oder. 1908. xx, 557 p. 8°.

**Belgium. Observatoire royal.**
Annales. Nouvelle série. Physique du globe. Tome 4. Fasc. 1. Bruxelles. 1908. 138 p. f°.

**Berliner Zweigverein der Deutschen meteorologischen Gesellschaft.**
Jahresbericht. 1908. Berlin. 1909. 39 p. 8°.

**Besson, Louis.**
Sur la théorie des halos. Paris. 1909. 89 p. (Thèse-Faculté des sciences de Paris.)

**Bürgel, Bruno H.**
Wetter-Kalender und kritische Tage. . . 1909. Berlin. 1909. 96 p. 24°.

**Calvert, Philip P.**
Relations of the odonate fauna of Mexico and Central America to temperature, rainfall, vegetation areas and altitude. (*From* Proceedings of the Academy of natural sciences of Philadelphia, Oct., 1908. p. 473-491.) [Contains temperature chart of Mexico and Central America.]

**Carnegie institution.**
Year book. No. 7, 1908. Washington. 1909. vii, 240 p. 8°.

**Congo. État indépendant.**
Climatologie. Diagrammes et cartes pluviométriques du Congo. (*From* Bulletin official de l'état independant. N. 5, Mai 1908. p. 167-189. 8°.)

**Costanzo, G., & Negro, C.**
Sopra alcuni fenomeni di ionizzazione ottenuti con l'acqua piovana. Roma. 1908. 9 p. f°. (Estr. Memorie della Pontificia accademia Romana dei nuovi lincei. v. 26.)
Sulla formazione della pioggia. Milano. 1909. 22 p. 8°.

**Craig, J. I.**
The climate of ancient Palestine. Alexandria. 1909. 3 p. 4°. (Reprinted from the "Cairo scientific journal," no. 27, 1908.)
A meteorological expedition to Addis Abbaba in 1907. Alexandria. 1909. 5 p. 4°. (Reprinted from the "Cairo scientific journal," no. 27, 1908.)

**Davis, W. M.**
Practical exercises in physical geography. Boston. 1908. xi, 148 p. 12°.

**Diaz, Severo.**
. . . Un temporal de invierno. Primeros pasos en la meteorológia de precisión. México. 1908. 12 p. 8°.

**Djebaroff, Iw. As. Th.**
Ein Beitrag zur Wasserverdunstung des nackten und bebauten Bodens. Halle a. S. 1907. 152 p. 8°. (Inaug.-diss.-Halle. a. S.)

**Ebstein, [Wilhelm].**
Eisenach, seine Heilfaktoren und seine medizinische Bedeutung. Jena. 1906. ix, 104 p. 8°. ["Das Klima," p. 29-58.]

**Egypt. Survey department.**
Meteorological report. Parts 1-2. Cairo. 1908. 65; vii, 202 p. f°.

10——4

**Ekholm, Nils.**
Om lufttryckets ändringar och därmed sammanhängande företeelsen. (Ur Ymer, Tidskrift utgifven af Svenska sällskapet för antropologi, och geografi, Arg. 1908, H. 4.)

**Elsner, Georg von.**
Wissenschaftliche Ergebnisse der Expedition Filchner nach China und Tibet 1903-1905. IX. Band. Barometrische Höhenmessungen und meteorologische Beobachtungen. Berlin. 1908. viii, 236 p. 4°.

**Fischli, Fritz.**
Das Verhalten der meteorologischen Elemente und Erscheinungen in der Vertikalen. Bern. 1908. 129 p. 8°.

**Fleming, J. A.** An elementary manual of radiotelegraphy and radiotelephony. New York. 1908. xiv, 340 p. 8°.

**Fortier, Samuel.**
Climate of Orland [Cal.] and vicinity. (*In* Irrigation in the Sacramento valley, California. U. S. Office of experiment stations. Bull. 207.)

**Fox, Chas. J. J.**
. . . On the coefficient of absorption of the atmospheric gases in distilled water and sea water. Part 2: Carbonic acid. Copenhagen. 1909. 31 p. 4°. (Conseil permanent international pour l'explorations de la mer. Publications de circonstance no. 44.)

**Fritsche, H.**
Die mittlere Temperatur der Luft im Meeresniveau, dargestellt als Funktion der geographischen Länge, Breite und Jahreszeit. Meteorologische Publication 1. Riga. 1909. 144 p. 4°.

**Germany. Deutsche Seewarte.**
Deutsches meteorologisches Jahrbuch 1907. Hamburg. 1908. vi, 200 p. f°.

**Gerosa, Giuseppe.**
Elementi di meteorologia. . . Livorno. 1909. x, 316 p. 8°.

**Grothe, Hugo.**
Meteorologische Stationen in der asiatischen Turkei. (S.-A. Beiträge zur Kenntnis des Orients. Band 6, p. 149-154.)

**Hecker, Alfred.**
. . . Die gestrengen Herren. (Landwirtschaftliche Jahrbücher. Berlin. 1908. p. 711-729.)

**Holland. Koninklijk nederlandsch meteorologisch Instituut.**
Jaarboek. 1907. Utrecht. 1908. xxxiii, 256; 38 p. f°. (No. 97.)
Onweders, optische verschijnselen, Enz. in Nederland. . . 1906. Deel 27. Amsterdam. 1908. 121 p. 8°. (No. 82.)

**Hungary. Magyar kiralyi orszagos meteorologiai és földmagnességi intézet.**
Die Erdbeben in Ungarn 1900, 1901, 1902. Budapest. 1909. 91, x, 1 p. 8°.

**Jensen, Chr.**
Die gegenwärtigen Probleme und Aufgaben welche mit dem Studium der atmosphärischen Polarization verknüpft sind. Kiel. 1908. [166]-175 p. 4°. (Abdruck aus den Astr. Nachr. Nr. 4283. Bd. 179. November, 1908.)

**Jersey. Observatoire St. Louis.**
Bulletin des observations météorologiques. 15 année 1908. Jersey. 1908. 31 p. 4°.

**Knörzer, Alb.**
Die Temperaturmittel Würzburgs 1880-1903. Eichstätt. 1904. 16 p. 8°.

**Krakau. Observatoryum.**
Materyaly do klimatografii Galicyi zebrane przez Sekcye meteorologiczna w roku 1907. [Krakow.] 1908. 77 p. 8°.

**Laflamme, C.**
Notes de météorologie. Quebec. 1904. 15 p. 8°.

**Lecornu, J.**
Les cerfs-volants. Paris. 1902. iv, 240 p. 8°.

**Leon, Luis G.**
Los fenomenos del aire. Mexico. 1900. 409 p. 12°.

**Loanda. Observatoiro meteorologico.**
Resumo das observaçoes. 1905-1908. 4 sheets. 38 x 50 cm. (1907-1908: 50 x 65 cm.)

**McAdie, A[lexander] G.**
Mountain sites for observatories. (*In* Publications of the Astronomical society of the Pacific. v. 21. Feb., 1909. p. 13-18.)

**Merzifun (Asia Minor). Anatolia college.**
Meteorological records. 1908. 1 sheet. 36 x 24 cm.

**Müller-Pouillet.**
Lehrbuch der Physik und Meteorologie. 10th ed. 2er Band. Braunschweig. 1909. xxvii, 1189 p. 8°.

**Mysore. Meteorological department.**
Meteorology in Mysore. 1907. 15th annual report. Bangalore. 1908. xiii, 56 p. f°.

**Navaro, Manuel Maria S.**
Datos sobre los macrosismos españoles. (Boletin de la Real sociedad española de historia natural, octubre, 1908.)

**Nowack, Jos. Fried.**
. . . Den Zweiflern. Entgegung auf die Kritiken über meine "Wetterpflanze." 2d ed. Korneuburg. 1905. 94 p. 8°.

**Oña (Spain). Colegio Maximo de la Compañia de Jesus.**
Observaciones meteorológicas. 1908. Oña. 1909. 34 p. 8°.

**Patxot y Jubert, Rafel.**
...Observacions de Sant Feliu Guixols resultats del 1896 (parcial) al 1905. Barcelona. 1908. 306 p. f°. (Meteorologia Catalana.)

**Philippine weather Bureau.**
Annual report of the director, 1906. Part 1. Manila. 1908. 153 p. 4°.

**Polis, P[eter].**
Funkentelegraphische Uebermittlung von Witterungsnachrichten auf dem atlantischen Ozean. Ergebnisse einer Studienreise im August 1908. (S.-A. Marine-Rundschau.) Berlin. [1908.]

**Prussia. Königl. preussisches meteorologisches Institut.**
Ergebnisse der Beobachtungen an den Stationen II. und III. Ordnung...1903. Berlin. 1908. xvi, [123]-267 p. f°.
Ergebnisse der magnetischen Beobachtungen in Potsdam 1903 und 1904. Berlin. 1908. xxxxiv, 120 p. f°.
Ergebnisse der meteorologischen Beobachtungen in Potsdam 1905. Berlin. 1908. vi, 107 p. f°.
Same. 1906. Berlin. 1908. viii, 106 p. f°.
Ergebnisse der Niederschlags-Beobachtungen im Jahre 1906. Berlin. 1908. xxxiv, 165 p. f°.
Ergebnisse zehnjähriger Gewitterbeobachtungen in Nord- und Mitteldeutschland. Von Th. Arendt. Berlin. 1008. 57, 152 p. f°. (Abhandlungen Bd. 2. Nr. 2.)
Die Expedition des Königlich preussischen meteorologischen Instituts nach Burgos in Spanien zur Beobachtung der totalen Sonnenfinsternis am 30. August 1905. Von G. Lüdeling und A. Nippoldt. Berlin. 1908. 92 p. f°. (Abhandlungen Bd. 2. Nr. 6.)
Barometrische Teildepressionen und ihre wellenförmige Aufeinanderfolge. Von W. Wundt. Berlin. 1904. 25 p. f°. (Abhandlungen...Bd. 2. No. 5.)

**Richardson, H. W.**
Relations of the U. S. Weather bureau to the railroad man. (*In* official proceedings of the Northern railway club. Duluth, Minn. Jan., 1907. p. 22-31.)

**Saxony. Königl. sächsische Landes-Wetterwarte.**
...Ergebnisse der meteorologischen Beobachtungen 1904. Dresden. 1908. 88 p. f°.

**Schwere, S.**
Wetterinstrumente, Wetterkarten und die Wettervoraussage. Zürich. [1908] 39 p. 8°.

**Steinmetz, Helmuth.**
De ventorum descriptionibus apud Græcos Romanosque. Gottingæ. 1907. 88 p. (Inaug.-diss.—Gottingen.)

**Timberg, Gustaf.**
Populär meteorologi... Stockholm. 1908. viii, 206 p. 4°.

**Yuriev, [Dorpat].**
Sammlung von Arbeiten, ausgeführt von Studenten am Meteorologischen Observatorium der Universität zur Jurjew (Dorpat). Band 2, 1908. Yuriev. 1909. 183 p. 8°.

## AN ANNOTATED BIBLIOGRAPHY OF EVAPORATION.

By MRS. GRACE J. LIVINGSTON. Dated Washington, D. C., January 8, 1908.

[*Continued from the Monthly Weather Review, November, 1908.*]

1870—*Continued.*

**Dufour, Charles, and F. A. Forel.**
Recherches sur la condensation de la vapeur aqueuse de l'air au contact de la glace et sur l'évaporation. Bul. soc. vaud. sci. nat., 1870, **10**:621-84; Les mondes, 1871, **26**:129-36, 183-9, 242-51. Abstracted in Arch. sci. phys. et nat., 1871, **40**:239-73; Ann. chim. et phys., 1871, **25**:80-1; Naturforscher, 1872, **5**:59-60.

A study of the hygrometric action of glaciers on the atmosphere and vice versa. Conclusions: (1) With air having a vapor pressure less than 4.6 millimeters condensation or evaporation will take place at the surface of the glacier according to the relative pressures of the water vapor of the air and that of the ice. These actions tend to counterbalance each other. (2) Condensation takes place whenever the atmospheric vapor pressure is above 4.6 millimeters. (3) The total result of condensation and evaporation must be very much in favor of the latter. (4) The glacier by these counteracting influences tends to restore the pressure of the water vapor in the air to 4.6 millimeters, except in the case of condensation at temperatures lower than zero. (5) Since, in the latitudes studied, the average hygrometric capacity of the air is above 4.6 millimeters pressure, the glacier exercises a very powerful drying influence on the atmosphere. (6) Condensation tends to prevent the extension of the glacier owing to the heat which it frees.

**Forel, F. A., and Charles Dufour.**
See Dufour, Charles, and F. A. Forel.

**Hajech, Camillo.**
Ricerche sperimentali sull' evaporazione di un lago. Rend. r. ist. lomb., 1870, **3** (2):785-90.

Compares the evaporation from three similar instruments exposing a free water surface 1 decimeter square, one floating on the surface of the lake, the second on land near the the lake, and the third on land, but farther from the lake. The results obtained from August 31 to October 7, show: (1) The maximum mean hourly evaporation occurred from all three on the same days, viz, September 16 and 17. (2) The quantities evaporated from the three in the daytime, were to each other as 100:140:140; when the sky was cloudy as 100:130:130; after sunset as 100:156:225; and for the entire day as 100:150:180.

**Henry, D. Farrand.**
Tables of evaporation from observations of the survey of the northern and northwestern lakes. Tables showing comparative readings of evaporators in lake and river, open air, and water. Rpt. Chief Eng., 1870: 570-3.

A table of results shows the difference between simultaneous readings of the evaporator at the meteorological stat'on and one placed in the water at Youngstown, N. Y., from June 11, to September 23, 1869. Evaporation was greatest on land, the ratio between the two being 0.558. Thermometric observations of the air, of the surface of the water in the evaporators, and in the lake showed no definite ratio between the water temperature and the rate of evaporation.

**Lamont, Johann von.**
Langsam Verdunstung des Wassers in engen Röhren. Münch. Stern. Wochenbl., 1870, (—):263.

**Moscati, Pietro.**
Lettera al Signor de Saussure con la descrizione d'un atmidometro e d'altre macchine altinenti alla meteorologia. n. p. 1870. 4to.

**Pfaff, A. B. I. F.**
Ueber den Betrag der Verdunstung einer Eiche während der ganzen Vegetationsperiode. Sitzber. k. bayer. Akad. Wiss. math. phys. Kl., 1870, **1**:27-45. Also Ber. Phys. Med. Soc., 1870, **2**. Abstracted in Zeits. Oest. Ges. Met., 1871, **6**:10-2. Also Naturforscher, 1871, **4**:85-7. Also Gaea, 1871, **7**:247-9.

See Hann, 1871, for the results of Pfaff's experiments.

**Risler, E.**
Evaporation du sol et des plantes. Arch. sci. phys. et nat., 1870, **37**:214-28. Also Zeits. f. Naturw., 1872, **6**:117-9.

The monthly evaporation during 1869 from soil of different depths is calculated from the difference between the amount of rainfall and the amount artificially drained off, the latter amount being at least partially corrected by a periodic determination of the moisture content of the soil.

**Somerville, Mary.**
Physical Geography. London. 1870. 6th ed. p. 223.

The fact that the sea water of the Southern Hemisphere contains more salt than that of the Northern is suppo ed to be due to the greater evaporation in the former, caused by the southeast trade winds blowing over a greater expanse of water than the northeast. It is computed that 186,240 cubic miles of water are evaporated (annually ?) from the surface of the globe, chiefly from intratropical seas. This would cause a lowering of the sea level by 5 feet annually. The equilibrium in these seas, thus disturbed, is restored by means of currents.

**Strachan, Robert.**
Lamont's vaporimeter. Symons's met. mag., 1870, **5**:73-4.

For a description of this instrument see Lamont, 1869.

**Symons, G. J.**
On evaporation. Brit. rainf., 1870, (—):175-83, (app.).

Experiments were carried on at Strathfield Turgiss with different evaporators, including Howard's, Miller's (a tin vessel with overflow, felt protected), Miller's sand evaporator, a glazed earthenware jar set in the ground, a glass cylinder, Proctor's, Sharples', Fletcher's, etc., of various sizes, etc. Observations on the temperature of the water in each showed that vessels which absorb heat most readily allow much more evaporation than others. A table gives the amount of evaporation for 1870 at various localities in Great Britain, with a description of the methods employed. The large tank used at Strathfield Turgiss is especially notable.

**Vogel, K. A.**
Versuche über die Wasserverdunstung auf besätem und unbesätem Boden. Abh. k. Bayer. Akad. Wis. math. phys. Kl., 1870, **10**:321-55.

From experiments similar to those of his previous paper (see 1868) it is concluded that evaporation is greater from limestone soil than from clay soil; greater from unplanted soil, both clay and limestone, than from planted; but greater from peat soil when planted than when unplanted. Results obtained with the "atmidometer, (see Vogel and Reischauer, 1856), showed differences similar to those observed in the absolute humidity of the air over the different soils.

1871.

**Buchan, Alexander.**
Introductory Text-book of Meteorology. Edinburgh. 1871.

See Buchan, 1868, for an account similar to that on p. 88-91 of this work.

**Casella, L.**
Catalogue of Scientific Instruments. London. 1871. 8vo. p. 24.

Two metal vessels are described for measuring evaporation from a free water surface, also a recording instrument, in which the changes in the level of a water surface are communicated to a recording cylinder by means of a float and pulley. Doctor Babington's "atmidometer" for measuring evaporation from water, ice, or snow, is mentioned on page 21, but not described.

**Dines, G.**
Reply to "On Evaporation of Water," by Henry Hudson in Symons's met. mag., 1871. Symons's met. mag., 1871, **6**:190-2.

The following statements, made in a previous article, 1870, are reaffirmed: "When the air is saturated with moisture and the water is of the same temperature as the air, neither evaporation nor condensation can take place." "Except as it affects the dew-point, it is a matter of little consequence whether the air is saturated or not; other circumstances being the same, it is the difference between the temperature of the water and that of the dew-point which determines the amount both of evaporation and condensation." The author's experiments with the wet- and dry-bulb thermometers in obtaining the dew-point lead him to think that they can never give more than an approximation to the moisture in the atmosphere Hudson's conclusion that water may evaporate at a temperature several degrees below the dew-point when the air is nearly saturated is refuted.

**Dufour, Louis.**
Sur le siccimètre. Ann. chim. et phys., 1871, **23**:78-80.

The siccimeter is designed to measure the difference between evaporation and rainfall (see Dufour, 1869.)

**Hann, Julius.**
Ueber den Einfluss der Bäume auf die Feuchtigkeit der Atmosphäre und des Bodens. Zeits. Oest. Ges. Met., 1871, **6**:10-12.

The experiments of Unger, 1861, Vaillant, 1865, and Pfaff, 1870, in attempting to calculate the total evaporation from a large tree by means of the observed amount evaporated from a single branch are here reviewed. According to Pfaff an oak tree having 700,000 leaves, each with a surface of 2,325 sq. mm., would evaporate from May 18 to October 24, 120,000 kg. This means an evaporation from the surface of the ground which the tree covered, of 5.39 meters while the rainfall for that area is only 0.65 meter. According to Hann, however, this does not show the amount that would evaporate under natural conditions. In the woods the temperature is low, the humidity is high, and the air movement very sluggish. At night evaporation ceases and dew is formed, and in the daytime only a very small portion of the leaves at the top are subjected to the conditions under which the branches were placed in Pfaff's experiments.

**Hann, Julius.**
Verdunstung auf den Azoren und auf Madeira. Zeits. Oest. Ges. Met., 1871, **6**:411.

Table of monthly percentage of clouds, evaporation in millimeters, wind velocity, etc., from December [1854?] to January, 1857.

**Hoffmann, H.**
Untersuchungen über die Bilanz der Verdunstung und des Niederschlages. Zeits. Oest. Ges. Met., 1871, **6**:177–81. Versuchsstat. Org., 1872, **15**:95–104. Abstract in Naturforscher, 1871, **4**:324–5. English abstract by Robert Warington, in Jour. Chem. Soc., 1872, **10**:1038–9.

Reviews the work of Unger, Schübler, Laws, Hartig, Saussure, Pfaff, etc. Unger's observations that a water surface evaporates about three times as much as a plant of the same surface, and that a forest in leaf evaporates much more than a water surface of the same area as the ground covered by the forest, are contradicted by Hartig who showed that evaporation from a water surface or from bare soil is greater than from a forest. Schübler's results are quoted, showing daily evaporation to be, from a water surface, 1 line; from turf, 2 to 3 lines; from bare soil, 0.60 lines; and from forest, 0.25 lines.

The author's own experiments, at the Botanical Garden in Seissen, Germany, with evaporation from a water surface in a glass vessel, showed a total amount lost by evaporation from May to September for 3 years (1855–8) to be 55.86 inches, with a rainfall of 45.68 inches. The author believes, however, that soil would not lose moisture at the same rate as the water surface in the experiment, the upper layers of the soil protecting the lower. He considers it important, therefore, in a dry climate to keep the soil covered with moss or dead leaves to prevent its drying out.

**Hudson, Henry.**
On evaporation of water. Symons's met. mag., 1871, **6**:166–8.

Challenges the conclusions drawn by Dines, 1870, concerning the point at which water will cease to evaporate and condensation will begin, and apparently concludes that water will evaporate when at a temperature several degrees below the dew-point.

The statements in this paper are vague and were later refuted by Dines, 1871.

**Mann, R. J.**
On evaporation, rainfall, and elastic force of vapor. Proc. Brit. met. soc., 1871, **5**:285–97. Also London. 1871. 8vo.

From experiments with evaporation of water at different temperatures, the following formula is derived: The depth of evaporation in inches per hour $= 1.5\sqrt{T+\left\{1-\left(\frac{e}{e_1}\right)\right\}D}$ where $T=$ the absolute temperature (°F.) of the surface of the water (that is, 461°+ the ordinary scale); $e=$ the vapor pressure in inches in air; $e_1=$ the vapor pressure at the temperature of the evaporating water, and $D=$ the density in pounds avoirdupois per cubic foot of the vapor at the temperature of the water. Altering the formula so as to use Glaisher's hygrometric tables only, a complicated expression is deduced, together with a simpler one which is sufficiently approximate. The latter is as follows: $E=0.04\times$ (the vapor pressure at the temperature of the water)—(the vapor pressure at the temperature of the air), i. e., $E=0.04\,(e_1-e)$. It is concluded that evaporation depends almost wholly on the three factors, the area of the water surface, the temperature of the water at its surface, and the vapor pressure in the air above the water. The retarding influence of the height of the rim of the vessel above the evaporating surface is also shown. Experiments with evaporation from sea water resulted in a rate of evaporation 5 per cent smaller than that from fresh water. The evaporation from the eastern side of the North Atlantic is calculated at 58.56 inches annually.

**Risler, E.**
Évaporation du sol et des plantes. Arch. sci. phys. et nat., 1871, **42**:220–63. Zeits. f. Naturw., 1872, **6**:117–19.

Continuation of the author's paper of 1870.

1872.

**Abbot, Francis.**
Results of five years' meteorological observations for Hobart Town, with which are incorporated the results of twenty-five years' observations previously published by the Royal Society of Tasmania, and completing a period of thirty years. Tasmania. 1872. 8 p.

A pluviometer and an evaporator were employed for these observations. The latter is a dish 5 inches in diameter, having an overflow pipe a little below the rim. A table shows the total excess of evaporation over rainfall at Hobart Town for the five years 1866–70 was 95.58 inches. The average annual evaporation is 42.18 inches and the rainfall 23.06 inches.

**Buys-Ballot, C. H. D.**
Ueber die Verdunstung von einer Wasseroberfläche. Zeits. Oest. Ges. Met., 1872, **7**:223–5.

Refers to the work of Schulze, Vogel, Vivenot, Field, and Symons. Emphasizes the need of having a large evaporating surface, also the need of protecting the walls of the vessel either by sinking it in the ground or placing it in a larger reservoir of water. A table of results obtained by A. Erlich Sterk with two instruments, one small and unprotected, the other a large cylinder placed in a larger reservoir, shows a difference of 250.5 millimeters in a year. The difference is greater in the daytime than at night, 209 millimeters for the former and only 41.7 millimeters for the latter. The author obtained only 70 millimeters difference in similar experiments, but his smaller instrument was somewhat shaded.

**Buys-Ballot, C. H. D.**
Suggestions on a uniform system of meteorological observations. Utrecht. 1872. 56 p.

Advises uniformity of apparatus for measuring evaporation.

**Buys-Ballot, C. H. D.**
Indications de deux évaporimètres, l'un exposé selon la manière habituelle, l'autre nageant dans l'eau libre, ou dans un très-grand réservoir. Bul. int. de l'obs. de Paris, 4 Juin, 1872.

**Fritsch, Karl.**
Bemerkungen über die Beobachtungen mit dem Verdunstungsmesser. Zeits. Oest. Ges. Met., 1872, **7**:124–7.

Emphasizes the important influence which the exposure of the atmometer may exert on the rate of evaporation. Summarizes the results of observations at Prague from 1833–37, at Vienna from 1868–70, by Vivenot in 1866–7, and Schenzl in 1863–5.

**Karsten, Gustav.**
Luftfeuchtigkeit, Niederschläge, Verdunstung, in den Herzogthümen. Beiträge zur Landeskunde der Herzogthümer Schleswig und Holstein. Reihe II, Heft II. Berlin. 1872. 4to.

**Lemoine, G.**
On the relation of forests to hydrology. Paper read to the British Association, Brighton meeting, 1872. Abstract in Symons's met. mag., 1872, **6**:161.

Describes experiments by Chapman on evaporation in South Africa. Two jars were sunk in the ground, one protected by a bush and the other in cleared ground. The rate from the latter jar was more than double that from the former. The evaporation during the hot, windy, dry season of the district, is believed to exceed by 384,000 gallons, the amount that would have been evaporated if the bush and grass had not been burned off.

**Moureaux, Th.**
Note sur l'atmismomètre de M. Piche. Bul. int. de l'obs. de Paris, 2, 3, Juin, 1872.

**Pfaff, Fr.**
Versuche über Verdunstung. Zeits. Deut. Geolog. Ges., 1872, **24**:401–9.

The evaporation at Erlangen from pure water and from a 2.5 per cent salt solution for a year resulted in totals of 750 and 659 millimeters, respectively, or as 100 to 87. Observations of evaporation from pure water for the two years previous, and of the rainfall, which in all three years surpassed the amount evaporated from salt water, led to the conclusion that salt could not be obtained here by natural evaporation from a bay separated from the ocean.

**Piche, Albert.**
Note sur l'atmismomètre, instrument destinée à mesurer l'évaporation. Bul. assoc. sci. de France, 1872, **10**:166–7; also Sci. pour tous, 1872, **17**:226; Ann. sci. ind., 1872, **16**:58–60; and Zeits. Oest. Ges. Met., 1873, **8**:270–1.

This instrument consists of a vertical graduated glass tube, 1 centimeter in diameter 23 to 30 centimeters long, closed above and provided with a ring by which it can be suspended. The tube is filled with water, a circular piece of moist blotting paper with an area of 8 square centimeters, is clamped over the open end, the whole inverted and the water allowed to evaporate from the surface of the paper. The differences in the height of the water in the tube give the amounts evaporated. A minute opening in the center of the paper allows air to rise and take the place of the evaporated water.

**Prettner, Johann.**
Ueber einen einfachen Verdunstungsmesser. Zeits. Oest. Ges. Met., 1872, **7**:319.

Describes a metal vessel in which to expose a surface of water for evaporation. A fixt needle point marks the standard level.

**Ragona, D.**
Sulla evaporazione dell' aqua salea. In Lettere meteorologiche al conte G. Vimercati. Rev. sci. ind., 1872. Also Florence. 1872. 8vo.

**Symons, J. G.**
On evaporation. Brit. rainf., 1872, (—):11–15.

Refers to a self-recording atmometer devised by Symons and Field. A table shows the rate of evaporation in different localities, measured by various methods. Evaporation was generally 10 to 15 per cent less in 1871 than in 1870. A table of monthly evaporation in the neighborhood of Manchester is appended.

**Volpicelli, Paolo.**
Sulla evaporazione dei liquidi, favorita della elettricità. Att. r. accad. Lincei, 1872, **25**:63–6.

Provenzali, in the Rev. sci. ind. de 1871, p. 119, stated that, "The action of static electricity on the evaporation of liquids is a fact that has generally past unnoticed, neither do I know that any one has ever closely examined it." Volpicelli shows that this statement is ungrounded, since many eminent investigators have attempted to solve this problem. He describes the researches of Cavallo, Hermbstadt (See Hermstädt, 1801), Van Marum, Schübler, Muncke, Nollet, and Beccaria. With the exception of Van Marum and Muncke, who obtained negative results, all the experiments together with his own which he describes have shown that electrification of water increases the evaporation from it.

1873.

**Buys-Ballot, C. H. D.**
A sequel to the suggestions on a uniform system of meteorological observations. Utrecht. 1873.

See Buys-Ballot, 1872, 1st title.

**Decharme, C.**
Effets frigorifiques produits par la capillarité jointe à l'évaporation; évaporation du sulfure de carbone sur du papier spongieux. (Extrait). Compt. rend., 1873, **77**:998, 1157.

A porous paper dipping into carbon bisulphide and supported in the air, is described as a very simple hygroscope. The drier the air, the less the cooling, the less rapid the evaporation, and the less the deposit of crystals.

**Delesse, A. and A. de Lapparent.**
Influence des forêts sur la quantité de pluie et sur l'évaporation. Rev. geol., 1873, **11**. Also Bul. assoc. sci. de France, 1873, **12**:190–1.

**Dufour, Louis.**
Observations siccimètriques à Lausanne. Bul. soc. vaud. sci. nat., 1873, **11**:151–62, 329–32; 1873, **12**:162–9.

Continuation of Dufour, 1870.

**Ebermayer, E.**
Die physikalischen Einwirkung des Waldes auf Luft und Boden, und seine klimatologische und hygienische Bedeutung. Aschaffenburg. 1873. Abstracts in Zeits. Oest. Ges. Met., 1873, **8**:253-5; and in Fortsch. f. Met., 1873: 140-5.

Evaporation from a free water surface in a forest is found to be about 64 per cent less than in the open, both summer and winter. The loss from the surface of a saturated soil, 6 inches deep, is three or four times less in the forest than in the open. Evaporation from two soils, one covered with straw, the other bare, is compared and found that the litter contributes as much to the holding of soil moisture as the forest itself. The amount evaporated in the open during six summer months was 409 mm., while from bare forest soil it was 158 mm., and from forest soil covered with litter only 62 mm. These observations illustrate the influence on river supply exerted by the presence of forests.

**Lapparent, A. de, and A. Delesse.**
See Delesse, 1873.

**Leslie, Alexander.**
On rainfall and evaporation in its relation to water supply. Trans. roy. Scot. soc. arts, 1873, **8**: 243-61.

A comparison of the annual rainfall with the run-off in the district of Reiroch Burn shows a loss of 12.72 in., as due to evaporation.

**Marié-Davy, H.**
Évaporation du sol et des plantes. Bul. mens. obs. phys. cent., 1873, **2**: 111-21, 155-62, 189-94.

It is stated that the rate of evaporation depends on the rate of movement of the air as measured by the anemometer, and on the difference between the elastic force of the vapor of the evaporating water and that of the vapor contained in the air, as measured by the psychrometer. Evaporation from plants and soils is determined by daily weighings of potted plants and pots of soil without plants. A table compares the evaporation from a Piche instrument with that from dishes of bare soil, the latter exhibiting from one to two times as great a rate as the former. Soil temperatures are deduced from the evaporation rate. Daily evaporation from growing grain (June, 1873), is compared with that from bare soil and from water with very varying results. Further experiments are elaborated along the same lines.

**Marié-Davy, H.**
Radiations solaires et évaporation des plantes. Bul. mens. obs. phys. cent., 1873, **2**:173-9.

In a study of the effect of color, as shown by observations of Déhérain on evaporation from leaves of maize in sunlight transmitted thru colored solutions, the highest rate of evaporation was produced under orange light, with red, blue, and green following in the order named.

**Miller, S. H.**
Evaporation. Brit. rainf., 1873, (—):204-8 (app).

The author attempts to discover "some law of relation between the amount of water evaporated and the temperature of evaporation or that of the dew-point," but does not obtain "such results as would give constants for evaporation." New evaporometers for use with soil are described.

**Mott, A. J.**
Periodicity of rainfall. Letter to the Editor. Nature, 1873, **7**:161.

General discussion of the relations between rainfall, evaporation, and wind. Solar spots, by causing temperature inequalities and the formation of barometric differences, are said to give rise to special areas of evaporation.

**Stefan, J.**
Versuche über die Verdampfung. Sitzber. k. Akad. Wiss. (Vienna), math. naturw. Kl., 1873, **68** (pt. 2):385-428. Abstracts in Zeits. Oest. Ges. Met., 1882, **17**:63-8; and Phil. mag., 1873, **46**:483-4.

From experiments with evaporation of ether from narrow tubes the following laws are deduced: (1) The velocity of evaporation of a liquid from a tube is inversely proportional to the distance of the surface of the liquid from the open end of the tube. This holds closely when the distance slightly exceeds 10 millimeters. (2) The rate of evaporation is independent of the diameter of the tube (for diameters between 0.3 and 8.0 millimeters). (3) The rate of evaporation increases with the temperature so far as this is accompanied by an increase in the vapor pressure of the liquid. When $p$ = vapor pressure of saturated air at the temperature of the observation, and $P$ = the atmospheric pressure under which the liquid evaporates, then the rate of evaporation is proportional to $\log \frac{P}{P-p}$. If the vapor pressure of the liquid equals that of the atmosphere this expression becomes infinity, and the liquid boils.

Also describes experiments in which the open end of an otherwise closed tube is dipt in ether. Bubbles are emitted from the tube and when the tube contains air the times in which successive equal numbers of bubbles form are at first proportional to the odd numbers. If the immersed tube contains hydrogen instead of air, the same number of bubbles form in one-fourth the time, whence he concludes that evaporation proceeds in hydrogen four times as rapidly as in air.

**Stevenson, Peter.**
Description of the atmometro-hygrometer. Trans. roy. Scot. soc. arts, 1873, **8**:160-3.

Two thermometers were inverted, the bulb of one being inclosed in one of Leslie's (1813) porous bulbs, the latter being kept wet by a cotton wick. The wick was fed from a glass tube reservoir with a graduated scale. From the indications of this instrument and by the use of Glaisher's hygrometric tables, the dew-point and relative humidity could be determined, and successive observations of the level of the water in the graduated tube gave the rate of evaporation.

**Symons, G. J.**
(Bibliography of evaporation.) Symons's met. mag., 1873, **8**:196.

The editor gives a short bibliography of the literature of evaporation.

**Symons, G. J.**
On evaporation. Brit. rainf., 1873 (—):203-4 (append.).

A table is presented of monthly evaporation at various points in Great Britain, as measured by different instruments. The results vary between annual totals of 7.96 inches and 40.26 inches.

A small metal dish, allowing evaporation from a free surface of water, is described, in which the level of the water is measured by a brass scale divided to hundredths of an inch. The temperatures of the water in this vessel, of the air, and of a running stream were compared on three different dates; the water in the evaporator was always at a higher temperature than that of the air or of the running stream.

## 1874.

**Bateman, J. F.**
Evaporation of snow. Proc. inst. civ. engin., 1874, **39**:34.

A discussion of Binnie, 1874, on the Nagpur Waterworks. Rapid evaporation of snow during the prevalence of an east wind was observed even at temperatures below the freezing point.

**Binnie, Alexander R.**
The Nagpur Waterworks; with observations on the rainfall, the flow from the ground, and evaporation at Nagpur, and the fluctuation of rainfall in India, and in other places, with discussion; edited by John Forrest. Proc. inst. civ. engin., 1874, **39**:1-32. Also quoted by Blanford, 1877.

The amount of water used by the city was calculated and subtracted from the total loss from the city storage reservoir. The difference between the two was taken as the amount lost by evaporation. By this method the total depth evaporated from October 10, 1872, to June 1, 1873, was 4 feet, giving a daily average of one-fifth inch. Of the total loss from the reservoir during the dry season 54 per cent was evaporated.

**Dufour, Louis.**
Observations siccimétriques à Lausanne. Bul. soc. vaud. sci. nat., 1874, **13**:371-5.

The average annual evaporation, as shown by the author's siccimeter (described by Dufour, 1869), for the seven years, 1865-73, is 738 millimeters; that for 1874 is 702.5 millimeters.

**Hough, G. W.**
Self-registering evaporometer and rain-gage. Nature, 1874, **9**:250. Noticed in Zeits. Oest. Ges. Met., 1874, **9**:93.

An evaporating vessel, 2 feet square and 1 foot deep, was supported on levers held in equilibrium by a small spring, so that any change in weight, due either to rainfall or evaporation was indicated on a scale. A continuous record was obtained upon a revolving drum by means of an electro-magnet and clock-work.

**Marriott, William.**
Tables for facilitating the determination of the dew-point from observations of the dry- and wet-bulb thermometers. London. 1874. 8vo.

**Osnaghi, F.**
Modification des Messverfahrens und autographische Einrichtung bei Verdunstungs Apparaten. Zeits. Oest. Ges. Met., 1874, **9**:54-6.

Describes weighing and registering apparatus of the type of Wild's spring balance (see Wild, 1874), and also possessing the advantage of recording during the winter.

**Scott, Robert H.**
Report of the Proceedings of the Meteorological Congress at Vienna. 1874. (p. 53-5, translation of the report of the Committee on Evaporation by Ebermayer.)

The committee adopted Leslie's term "atmometer" for an evaporation gage as possessing "the merits of seniority and a correct classical derivation." All atmometers were divided into two groups, those weighing the losses by a delicate balance, and those measuring the changes in volume. Theoretically the former gives the most accurate results, but requires much attention and very delicate balances; therefore, for general meteorological observations, those of the second class are recommended.

The requirements in a good atmometer of the second class are: (a) The evaporating dish should not be too small, and for comparative results the surfaces should be identical in all instruments. (b) The water level must be kept constant. (c) Reading should be accurate to millimeters in depth. Small instruments for scientific purposes should be sheltered with the thermometer and hygrometer; but for practical purposes larger instruments should be used and should be exposed to the sun and wind and compared with the rain-gage. Various instruments of both types are recommended.

**Wild, H.**
Ueber einen einfachen Verdunstungsmesser für Sommer und Winter. Bul. acad. imp. sci., 1874, **19**: col. 440-6. Also Repert. f. Met., 1874, **10**:273-8. Also Acad. sci. mét., **9**:51-61. Abstract in Chem. Centbl., 1874,(—): 465-6.

Attention is called to the fact that the rate of evaporation can not be determined by measuring the loss of volume when the temperature is below 0° C. The weighing method, e. g., as embodied in the instrument described (see Shaw, 1877), is the only one then possible. Wild gives a table of the mean daily evaporation, temperature, relative humidity, and wind velocity at the Central Physical Observatory at St. Petersburg during 1872-3. The mean daily evaporation varied from 0.12 millimeters in February to 2.83 millimeters in June, the average for the year being 0.98 millimeters, or a yearly total of about 350 millimeters. Contemporaneous experiments with an ordinary atmometer, exposing a surface of 1 sq. m., gave 1.4 times higher evaporation during the summer than did the Wild instrument.

## 1875.

**Brown, John Croumbie.**
Hydrology of South Africa; or details of the former hydrographic condition of the Cape of Good Hope, and of the causes of its present aridity, with suggestions of appropriate remedies for this aridity. London. 1875.

The phenomenon of evaporation is discussed on p. 158. On p. 194 et seq. are described experiments which were made by Mathieu, one of the directors of the Forestry School at Nancy, France, and published by the French government in the Atlas météorologique de l'observatoire Impérial for 1867. The rate of evaporation from a vessel of water placed in the ground and surrounded by trees was found to be about one-fifth of that from a similar vessel in the open. Experiments in the neighborhood of Capetown, S. Africa, showed the retarding influence upon evaporation produced by the protection from wind afforded by nearby vegetation.

**Decharme, C.**
Note sur l'évaporomètre au sulphure de carbon. Bul. assoc. sci. de France, 1875, **17**: 55-8. Also Bul. int. de l'obs. de Paris, 23 Oct., 1875.

The idea suggested in a paper by Decharme, 1873, is here developed. As the Piche instrument, with water, could not be used in time of frost, carbon bisulphide was placed in the tube instead of water. The formation, during the evaporation of this substance, of a thick border of frost on the paper was regarded as a factor whose relation with other meteorological phenomena might furnish useful indications. The curve of the rate of evaporation of carbon bisulphide was shown to be the inverse of that of water. Under average circumstances, causes favoring evaporation from water and retarding that from carbon bi-

sulphide are dryness, heat, and increase of vapor tension, but increased velocity of the wind acts in a similar manner upon both. Thus curious anomalies are produced in the correlative curves.

**Mohn, H.**
Grundzüge der Meteorologie. Berlin. 1875. Reviewed in Fortschr. f. Met., 1875.

A general definition of evaporation on p. 77-8.

**Wollny, Ewald.**
Der Verdunstungsmesser von Johann Greiner. Zeits. Oest. Ges. Met., 1875, **10**:255-6.

An evaporating dish, with vertical sides, and 113 millimeters in diameter, has a tube with a stop-cock leading from the center of its base. One hundred cubic centimeters of water are poured into the evaporating dish and left to evaporate for a certain time. The stop-cock is then opened and the remaining water drained into a graduated tube to measure the amount lost by evaporation.

1876.

**Greaves, Charles.**
On evaporation and percolation. Proc. inst. civ. engin., 1876, **45**: 19-47, 56-62. Also London, 1876. 8vo. Also abstract in Van Nostrand's engin. mag., 1877, **16**:48-52. Summarized by Fanning, 1889.

Careful experiments were made to determine the maximum and minimum, total and periodic quantities of (1) rain falling, (2) rain percolating thru soil and re-evaporated from it, (3) rain percolating thru sand and re-evaporated from it, (4) water evaporated from a water surface, and (5) their correlation. The gages used were constructed on the principle of Dalton's gage [see Dalton, 1802, (2)]. The most notable results obtained from these records were: (1) The great magnitude of percolation thru sand at all times; (2) the usual small amount of percolation thru ordinary soil; (3) the large evaporation from, and the entire absence of percolation thru ordinary soil in warm summer weather; (4) that in winter evaporation from soil exceeds that from a water surface, while in summer the evaporation from a water surface is the greater; (5) the shallow depth of the layer of soil below which water may be considered safe from loss by evaporation; (6) the great variations in the annual percolation. The maximum yearly evaporation from a water surface was 27 inches and the minimum, 17 inches. An appendix with 26 tables of results from 1860-73 is given on p. 56-62.

The discussion was continued by John Evans and Doctor Gilbert with accounts of their work along the same lines. Results of various observers are summarized, notably those of Ebermayer in Bavaria in 1873, and those obtained at Rothamsted, near Harpenden, Herts, 1870-5.

**Humber, William.**
A comprehensive treatise on the water supply of cities and towns. London. 1876. Imp. 4to.

Contains a chapter on rainfall and evaporation.

**Morgenstern, Ludwig.**
Ueber ein neues Atmometer. Repert. f. Met., 1876, **12**:520-38.

(See below, Symons, 1876, for description.)

**Murray, Digby.**
Ocean currents. Nature, 1876, **15**:76-7. Reviewed by Ramsay, 1884.

Discusses the cause of ocean currents, but does not decide whether the greater amount of evaporation occurs in the northern or the southern hemisphere.

**Stelling, Ed.**
Beobachtungen über Verdunstung in Tiflis von A. Noeschel bearbeitet von E. Stelling. St. Petersburg. 1876. 4to. Also Repert. f. Met., 1876, **5**: No. 9, 9 p. Abstract in Zeit. Oest. Ges. Met., 1877, **12**:315-6.

Evaporation in the sun and shade was observed from April to November, together with rainfall, temperature, humidity, cloudiness, and wind velocity. Daily observations during June and July, 1872, showed the rate from the atmometer exposed in the sun averaged 2.2 times that from the shaded one. Observations from May to September, 1875, gave the corresponding ratio as 2.6. The apparatus was built by A. Noeschel, and consisted of two communicating vessels, one 25.4 centimeters in diameter and 19 centimeters deep; the other, 5 centimeters in diameter and 19 centimeters deep. A float in the second indicated changes in level against a scale graduated to tenths of a millimeter, on the glass tube in which it was free to move.

**Symons, G. J.**
Account of the Loan Exhibition at South Kensington. Symons's met. mag., 1876, **11**:156-9.

Describes forms of evaporometers designed by Lamont, Osnaghi (see 1874), Skertchley, Ebermayer, and Morgenstern. Skertchley's apparatus consists of two vessels, one set within the other, the inner holding the evaporating water while the outer one is covered and acts as a reservoir. Over the whole is a glass vessel which receives the water vapor. Ebermayer's is a simple apparatus for determining the amount of evaporation from different kinds of soil.

Morgenstern's evaporometer presents a saturated surface of siliceous sand, the loss by evaporation from this surface being replaced by water from a burette forming a Mariotte's bottle. A tube entering from below supplies air as the water is withdrawn. The evaporating vessel is enveloped by some heat-insulating material.

1877.

**Baumgartner, Georg.**
Ueber den Einfluss der Temperatur auf die Verdampfungsgeschwindigkeit von Flüssigkeiten. Sitzber. k. Akad. Wiss. (Vienna), math. naturw. Kl., 1877, **75** (pt. 2): 679-88.

A mathematical discussion of diffusion coefficients after Stefan, 1873.

**Blanford, H. F.**
Meteorology of India. Indian Meteorologist's Vade-Mecum, pt. II. Calcutta. 1877. p. 16, 55, 100.

Regnault's formula for latent heat of evaporation is quoted as follows: $Q = 1091.7 + 0.305 (t-32)$ units of heat, where $Q$ is the total quantity of heat required to raise water from 32°F. and to evaporate it at $t$°F. A general discussion of evaporation and its effects is followed by tables of observations in India by Laidlay, 1845, and by T. G. Taylor at the Madras Observatory between 1830-43. Taylor observed the evaporation from a free water surface in a cylindrical copper vessel; the evaporation being increased by the action of the sun on the metal sides of the vessel, but, on the other hand, the surface was somewhat protected from the wind by the walls of the vessel. The mean daily evaporation for the thirteen years was 0.35 inch. Ludlow, 1846, found 0.25 inch per day, Binnie, 1874, in the very dry climate of Nagpur, found 0.198 inch from a large reservoir, and Jackson, 1885, found 0.125 inch per day from a tank.

From these results Blanford assumes 0.10 inch as the daily evaporation from the seas around India and estimates the total evaporation per square mile as 232,320 cubic feet, or a weight of 14,475,000 pounds, requiring, at 80°F., the absorption of 7,975,725,000 units of heat.

**Cantoni, Giovanni.**
Su l'evaporazione dell'acqua e delle terre, e sugli evaporimetri. Met. ital. sup., 1877 (pt. 1):56-61.

Results of experiments made from May 31 to June 8, upon the rate of evaporation from water, saturated coarse sand, and saturated finer sand, confirm the results obtained by Marcet, 1853, along the same lines. Similar results were obtained with another series of experiments from June 12 to July 9. The temperature was found to be much higher in the lower layers of sand than in the upper layers while it was but little higher near the bottom of the water than above. The temperature of the sand was uniformly lower than that of the water. Experiments showed a higher rate of evaporation from soils with vegetation than from those without. The results of a comparison of the rates of evaporation from different instruments emphasize the necessity of perfect uniformity in form, exposure, and management of atmometers in comparative studies. Other observations showed lower temperatures and less rapid evaporation in forested than in unforested regions.

**Frisiani, P.**
Sulla dipendenza dell' evaporazione dell' area e della figura della superficie liquida evaporante. Rend. r. ist. lomb., 1877, **10**:537-50.

Experiments with evaporation of water (1) from vessels of similar form and different area, (2) from vessels of equal area and different perimeter, (3) from vessels in which the surface of the liquid was at different levels, indicate that other factors besides the area of the surface complicate the phenomenon, and that, therefore, the relative indications furnished by different instruments are not comparable.

**Johnen, Adolf.**
Forstlich-meteorologische Beiträge. Centbl. Agr. Chem., 1877, Heft VI, 325-27. Abstract in Forsch. Geb. Agr. Phys., 1878, **1**:257-8.

A study of the relation of rainfall to evaporation at different stations with forest covers of different ages, disclosed the fact that the difference (rainfall-evaporation) increases as the forest becomes older.

**Léger, A.**
Hygrométrie et évaporométrie. Communication présentée à la société des sciences industriales de Lyon dans la séance du 27 Juin, 1877. Lyon. 1877. 8vo. 22 p.

**Marié-Davy, H.**
Evaporomètre et autres appareils enregistreurs de l'Observatoire de Montsouris. Jour. de phys., Paris, 1877, **6**:201-3.

The recording "evaporometer" here described consists of a weighing apparatus connected with a recording drum. Another form consists of a dish filled with water, in which floats a hollow ball of zinc, which by means of a rack on its stem operates the pinion of a pointer moving over a graduated dial. Snow and ice interfere with the operation of this instrument, but do not invalidate the self-registering balance first described.

**Milani, Gustavo.**
Corso elementaire fisica e meteorologia. Milan. 1877.

Statement of laws of evaporation and a discussion of the methods of measuring its rate on p. 698 and 1351.

**Miller, S. H.**
On a self-registering atmometer. Quart. jour. roy. met. soc., 1877, **3**:9-17.

Describes an elaborate arrangement in which the evaporating vessel, exposing a free water surface, is surrounded by a closed compartment divided horizontally into two sections. The upper section contains water, and is planned to maintain the evaporating surface at a constant level, the lower receives any overflow due to rainfall. The amount evaporated is determined by weighing the whole apparatus. Evaporation from this atmometer closely agrees with that from a tank 6 feet square.

**Ragona, D.**
Evaporimetro registratore. Ann. soc. met. ital., 1877, **1**:321-4.

——— Remarkable results of evaporation and rainfall. Sci. Amer., 1877, **36**:257.

A discussion of the general relation between evaporation and rainfall. The evaporation from the aqueous surface of the earth must be much greater than that from the land. Therefore practically only the evaporation from the aqueous surface or three-fourths of the whole surface of the earth provides the rainfall for the whole, and the evaporation from a given surface of land must surpass the amount of rainfall for that area. Seas which have no outlet, as the Great Salt Lake, Utah, and the Caspian, must become more and more salt as the inflowing water continues to evaporate.

**Shaw, William Napier.**
Report on evaporimeters. Comparison of observations of the rate of evaporation of water as given by different instruments. Quarterly Weather Report of the Meteorological Office for 1877. London. 1885. p (35)-(42).

Observations were made with evaporometers designed by Wild, Lamont, De la Rue, and Piche. The Wild instrument exposes a free water surface in a shallow cylindrical dish 17.8 millimeters in diameter supported on the short arm of a lever balance. The longer arm, acting as a counterpoise, ends in a pointer which moves over a graduated quadrantal arc, indicating the loss of weight due to evaporation. Lamont's instrument (see Lamont, 1868), with a diameter of about 3 inches, possesses two uncertainties in its manipulation: (1) The last portion of water drains but slowly from the pan when the piston is raised, so that one may obtain readings differing by several scale divisions according to the time that the pan is allowed to drain. (2) The annular space between the piston and cylinder supports by capillarity a variable amount of water, which introduces an error in the readings. A dust film on the surface also interferes with the action of evaporation.

In the De la Rue form the water evaporates from a surface of moistened parchment paper stretched over a shallow drum of 5 inches diameter supplied with water from a reservoir giving about 6 inches head and fitted with a constant level device. A graduated glass cylinder shows the amount lost by evaporation. It is intermittent in its action, as the water in the graduated vessel is replaced only by the ascending of large bubbles of air, and at times the slightest jar causes a rapid rise of bubbles, so that, with judicious shaking, any reading within wide limits may be obtained. The reading is sensibly affected by changes in temperature and pressure.

With the Piche instrument (see Piche, 1872) there are three difficulties: (1) A certain difference of pressure between the air inside and outside the tube is required to force the bubbles through the paper, and this may not be constant. (2) The condensation of water on the

sides of the tube on the water surface. (3) Considerable variations in temperature and barometric pressure affect this instrument as they do De la Rue's. Factors were determined for the reduction of the indications of the other instruments to those of the Wild. A table shows the percentage of difference between the corrected results. The Wild instrument seems to have become less and less sensitive as time elapsed, probably due to the formation of the dust-film which remained undisturbed on the evaporating surface. The following condensed table shows that evaporation decreases as the evaporating area increases:

| | Wild. | De la Rue. | Lamont. | Piche. |
|---|---|---|---|---|
| Area (square centimeters) | 245.8 | 125.6 | 49.2 | 11.1 |
| Total evaporation (millimeters) | 26.52 | 32.35 | 43.57 | 54.7 |
| Evaporation per square centimeter | 0.108 | 0.258 | 0.886 | 4.928 |

**Weilenmann, A.**
Die Verdunstung des Wassers. Schweiz. met. Beob., 1877, **12**:268, 368. Reprinted Zürich. 1877.

Derives the following formula for calculating the daily evaporation, $h$, from the temperature, psychrometer difference, and wind velocity:

$$h = \mu_1 \left( \Sigma \frac{m}{a+\lambda} + \gamma \cdot \Sigma \frac{mv}{a+\lambda} \right),$$

where $\mu_1$, $\gamma$, and $\lambda$ are constants to be determined from observation, $v$ is the wind velocity at the surface of the water in kilometers per hour, $a$ is the change in the vapor tension of saturated air for 1°C., $m$ is the saturation deficit in grams per cubic meter, and $\Sigma$ is the factor necessary to reduce the evaporation from observed time to a desired time. The results calculated by this formula closely agree with those actually observed.

**Weilenmann, A.**
Berechnung der Grösse der Verdunstung aus den meteorologischen Factoren. Zeits. Oest. Ges. Met., 1877, **12**:368.

Quantities calculated by the formula of the preceding paper closely agree with quantities observed at Vienna, September, 1874, to January, 1877, with a weighing apparatus, and at Montsouris from July, 1873, to April, 1875, with a Piche instrument.

**Zeithammer, L. M.**
Ueber die Wasserverdunstung des Bodens. Oest. landw. Wochenbl., 1877, (-):512.

## 1878.

**Bartoli, A.**
Sulla evaporazione: nota. Florence. 1878. 8vo. 10 p. Also Riv. sci. ind.

**Bebber, W. J. van.**
Die allgemeinen Niederschlagsverhältnisse mit besonderen Berücksichtigung Deutschlands. Forsch. Geb. Agr. Phys., 1878, **1**:341-76.

In connection with a discussion of humidity the author illustrates and describes the Piche evaporometer.

**Boussingault, Joseph.**
Études sur les fonctions physiques des feuilles: transpiration, absorption de la vapeur aqueuse, de l'eau, des matières salines. Ann. chim. et phys., 1878, **13**:289-393.

Experiments with transpiration from leaves showed great differences between sun and shade. Calculates that an acre of beets loses 8,000 to 9,000 kilograms of water in twenty-four hours.

**Cantoni, Giovanni.**
Sugli évaporimetri. Mem. met. ital., 1878 (pt. 4):67-71. Also Rome. 1879.

Reviews experiments by Tacchini, Ragona, Stefan, Bartoli, and Frisiani. They show, in general, the great influence of the design and exposure of the atmometer. Cantoni's experiments, compared the Piche, the Vivenot-Ragona, and the modified Piche (see Cantoni, 1879). He concludes that the different specific heats of the liquids and the different conductivities of the containing vessels were the chief causes for the observed differences in evaporation.

**Johnson, S. W.**
Studies on the relations of soils to water. Ann. rpt. Conn. agr. exp. sta. for 1877. New Haven. 1878. p. 76-81.

**Leslie, Alexander.**
See following entry.

**Leslie, John and Alexander Leslie.**
Notes on evaporation at Glencorse. Jour. Scot. met. soc., 1878, **5**:108-9.

Observed evaporation of water in an iron vessel 6 feet in diameter. Tables of monthly evaporation near the filters at Glencorse [Edinburgh] reservoir during 1857-76 show the yearly total varying between 14.70 inches in 1868 and 9.19 inches in 1866.

**Lorenz, J. R.**
Entwurf eines Programmes für forstlich-meteorologische Beobachtungen in Oesterreich. Mitt. forst. Versuchsw. Oest., 1878, **2**:73-91. Abstract in Forsch. Geb. Agr. Phys., 1878, **1**:248-57.

Considers observations of evaporation a necessary part of observational meteorology.

**Marié-Davy, H.**
Rapport au Ministre sur les travaux de l'observatoire de Montsouris pendant l'année 1876-7. Ann. de l'obs. de Montsouris, 1878, (-): 187, 323-7, 413-15, 456-7.

A general discussion of the evaporation of water. Describes the Piche atmometer, and the Delahaye, which consists of a protected tank with a float and self-recording instruments. Diagrams of evaporation and rainfall are reproduced.

**Mascart, E.**
Influence de l'électricité sur l'évaporation. Compt. rend., 1878, **86**:575-6. Also Les Mondes, 1878, **45**:461-3. Abstract in Proc. Inst. civ. engin., 1878, **53**:390.

The electric phenomena accompanying evaporation, observed by Volta and Pouillet, from which they concluded that evaporation is the source of atmospheric electricity, have been explained on the ground that the electric phenomena were due to the nature of the walls of the vessel, and not to the evaporation itself. Mascart's experiments show, however, that electricity accelerates evaporation.

**Miller, S. H.**
Prize essay on Evaporation. Utrecht. 1878. 4to. 27 p. Also Brit. rainf., 1890, (-): 17-29.

According to Symons, Miller gives average results of three years' experiments at Wisbech with evaporation from water, and from soil with and without vegetation, in the following table:

| Evaporating surface. | Annual evaporation. | Relative amounts. |
|---|---|---|
| | *Inches.* | *Per cent.* |
| Water | 17.02 | 100 |
| Peat | 13.62 | 80 |
| Sand | 14.03 | 83 |
| Clay | 13.58 | 80 |
| Garden mould | 15.12 | 89 |
| Garden mould (in shade) | 6.27 | 37 |
| Long grass | 48.16 | 283 |
| Short grass | 23.50 | 138 |
| Red clover | 53.44 | 314 |
| White clover | 31.15 | 183 |

**Modena, Reale Osservatorio**
Osservazioni sulla evaporazione. Ann. soc. met. ital., 1878, **1**.

**Ragona, D.**
Evaporazione all' aria libera e al sole. Ann. soc. met. ital., 1878, **1**:115-18.

**Ragona, D.**
Importance des observations relatives à l'évaporation. Compt. rend., 1878, **7**:491-2.

In the general expression for the amount of evaporation, which takes into account relative humidity, temperature, and velocity of the wind, the author found at Modena coefficients similar to those obtained by Tacchini at Palermo. The rate of evaporation in the sun was found to be nearly three times that in the shade. From the mean daily evaporation in sheltered shade the total annual evaporation in the open air and sun is computed at 2.611 meters. In discussing the paper Tacchini calls attention to the fact that measurements of evaporation for meteorological purposes are quite different from those made for agricultural purposes, the results with small tube atmometers used by meteorologists having no application to agriculture, where nothing less than a surface 1 meter square should be used.

**Thomson, C. Wyville.**
Geography. Opening address to Geographical Section of the British Association by the President. Nature, 1878, **18**:449. Abstract by Ramsay, 1884.

This paper includes a discussion of the influence of evaporation on ocean currents. The constant inward current through the Straits of Gibraltar is said to be necessary to keep up the supply of water in the Mediterranean, where evaporation is greatly in excess of the precipitation.

**Todd, Charles.**
Meteorological observations, made at the Adelaide Observatory, during 1876 and 1877. Adelaide. 1878. 246 p. Reviewed in Symons's met. mag., 1879, **14**:72-3.

The atmometer used in these experiments was similar to the large tank at Strathfield Turgiss. The average annual evaporation for the six years, 1870-5, was 67.309 inches, and the average annual rainfall was but 24.479 inches.

**Vogel, K. A.**
Ueber Wasserverdunstung von verschiedenen Vegetations-decken. Sitzber. k. bayer. Akad. Wiss., math. phys. Kl., 1878, **8**:539-45.

The number of grams of water in a cubic meter of atmosphere over different soils with different plant covers, was determined by means of a hygrometer. The results of earlier (1868) experiments are corroborated in the following points: (1) The evaporation from soil with vegetation is considerably greater than from soil without. (2) The kind of plant has a decided influence on the amount of water evaporated.

**Wheeler, W. H.**
Arterial drainage and the storage of water. Jour. roy. agr. soc., 1878, **14**:1-60.

Includes a discussion of the relations between evaporation and rainfall as bearing on the storage of water.

[*To be continued.*]

# THE WEATHER OF THE MONTH.

By Mr. P. C. Day, Acting Chief, Climatological Division.

## PRESSURE AND WINDS.

The distribution of the mean atmospheric pressure for February, 1909, over the United States and Canada is graphically shown on Chart VI, and the average values and departures from the normal are shown for each station in Tables I and III.

The average atmospheric pressure for the month was marked by several unusual features which influenced in a marked degree the weather of the month. The most pronounced feature was an unusual grouping of high-pressure areas over the southern districts, especially over the Gulf and South Atlantic States, and a marked absence of such areas over the interior and northern districts.

Areas of low pressure moved in rapid succession over the interior portions of the country, frequently from the Pacific to the Atlantic coasts, and while pursuing courses well to the south over the Mountain and Plains regions, they recurved sharply to the northeast while still west of the Mississippi River and moved to the Atlantic coast by way of the Ohio Valley, Lake region, and New England, bringing much cloudy, rainy weather to those districts, but leaving the east Gulf and South Atlantic States remarkably free from storm activity.

The pressure for the month was slightly above the normal near the south Atlantic and Gulf coasts, and from Texas westward to the Pacific, but over all other districts of the United States and Canada the average for the month was below the normal, being most pronounced in the interior districts where under normal conditions high pressure prevails during the winter months.

As compared with the previous month the pressure diminished rapidly from the Pacific coast eastward. Over the Pacific coast the average pressure exceeded that for January from 0.05 to 0.15 inch, while over the districts from the Rocky Mountains eastward the pressure ranged from 0.10 to 0.20 inch less than that for January. With the highest average pressure over the Gulf States and the Southwest, and low pressure over the interior and northern districts, the prevailing winds from the upper Mississippi Valley southwestward to Texas, and eastward over all districts to the Atlantic coast were from the south, carrying the moisture and warmth of the Gulf region far to the north and modifying the weather of the month accordingly.

The frequent passage of extensive areas of low pressure over the interior districts prevented any decided stagnation in the atmospheric circulation, and the month, as a whole, showed the wind movement decidedly above the average.

## TEMPERATURE.

The month opened with high barometric pressure and generally cold weather over the districts east of the Mississippi, but with moderate temperatures over all western districts. The cold weather of the 1st and 2d penetrated to the Gulf coast, and killing frosts occurred over the greater part of northern and central Florida.

Generally moderate temperatures for the season prevailed over all districts from the 2d to the 8th, when a decided cold wave appeared over the northern Rocky Mountain districts and moved east and southeast during the 9th and 10th, but with diminished intensity. Moderate weather again prevailed till about the 13th, when another high-pressure area covered the upper Missouri Valley, which by the 15th had developed into a cold wave of considerable severity over the districts between the Rocky Mountains and the Mississippi River with temperatures below the freezing point in extreme southern Texas. It moved eastward over the Ohio Valley, east Gulf and South Atlantic States with decreasing severity during the 16th and 17th, and moderate weather as to temperature prevailed over most districts during the remainder of the month.

The mean temperature of the first ten days was above the normal from 5° to 10° over all districts except eastern Maine, the southern coast of California, and at a few points near the Gulf coast. During the second decade the mean temperature continued above the normal in all districts except the upper Missouri Valley and the northern Rocky Mountain district. It was unusually warm over the Ohio Valley, Appalachian Mountains, and middle Atlantic coast regions, where the mean for the 10-day period averaged from 6° to 14° above the normal.

During the last decade of the month the mean temperature was also above the normal by substantial amounts over all districts, except locally in the southern portions of the Rocky Mountain and Plateau districts.

Over the greater portion of the Mississippi and Ohio valleys, lower Lakes, and Middle Atlantic States, the mean temperature for the month ranged from 5° to 10° above the normal, and over the northern portion of the Plateau region it ranged from 4° to 8° above.

Despite the unusual warmth prevailing during most of the month the minimum temperatures of the 1st and 2d over the east Gulf States and Florida Peninsula, and those of the 14th and 15th over Texas and portions of the west Gulf States, were unusually low, and freezing temperatures occurred over all portions of the Southern States, except extreme southern Florida and at a few points in the southern coast district of Texas. Over the Pacific coast States freezing temperatures did not occur in southwestern Arizona and the lower elevations of central California, and the immediate coast districts from southern California to northern Washington were exempt from frost.

Minimum temperatures from 20° to 30° below zero occurred in the mountain regions of Wyoming and Montana and thence eastward to the upper Lakes, and at points in northern New England, and at a few points in northern Montana and northern Minnesota temperatures from 36° to 48° below zero were recorded.

## PRECIPITATION.

The month was one of generally heavy and well-distributed precipitation over most of the interior districts, the storm areas moving with unusual regularity and persistence across the entire country from the Pacific to the Atlantic, and generally farther south than usual over the territory west of the Mississippi. These storm areas were frequently of wide extent and accompanied by heavy rains over the Pacific coast States, heavy snows in the mountain districts of the West, and by heavy rain, sleet, and snow in the middle Mississippi and Ohio valleys, Lake region, and New England. A very heavy sleet storm prevailed over the Ohio Valley, Lake region, northern portion of the Middle Atlantic States, and New England during the 14th to the 16th, doing much damage to trees, electric wires, etc. Heavy rains over the watershed of the Ohio River during the 22d to the 24th caused high waters in many of the streams in that region, and floods of considerable proportions prevailed in the main stream and some of its larger tributaries at the end of the month. High waters also prevailed in the rivers of northern California, due to heavy rains and melting snows over the surrounding watersheds.

Precipitation continued below the normal amount in Texas as in January, and rain was needed over much of that State. The month was also comparatively dry over most of the southern portions of the cotton-growing States, the rainfall being especially light over the Florida Peninsula. Over the Pacific coast precipitation was generally heavy and rain fell almost

daily during a large portion of the month. Over large portions of California, Oregon, and Washington precipitation was heavy and of almost daily occurrence from the 1st to the 25th. In portions of California precipitation was of almost daily occurrence from January 1 to February 25, inclusive, probably one of the longest periods of nearly continuous rainfall in the history of the State, and with amounts probably greater than ever recorded during a similar period of time.

As a result of severe storms in northwestern Arkansas during the last decade of the month thirteen persons were killed and considerable damage was done to property. Destructive windstorms occurred also in portions of eastern Texas, in Oklahoma, and at points in New Jersey.

### SNOWFALL.

The general distribution of the snowfall during the month is shown on Chart VII, from which it appears that appreciable amounts of snow occurred in all portions of the country, except near the south Atlantic coast, over the greater part of the Gulf States including most of Texas, and the lower elevations of Arizona and California, and along the immediate Pacific coast.

Amounts from 15 to 20 inches or more occurred over northern New England, and the Adirondack regions of New York, over the greater parts of Michigan, Wisconsin, and Minnesota and in parts of northern Iowa, eastern Nebraska, and South Dakota.

Over the mountain districts of the West the amounts varied generally with the elevation, small amounts being recorded at the lower elevations, while in the high ranges much heavier falls occurred.

In general, the snowfall over all the mountain States was above the normal, except in portions of Washington, Idaho, and Montana, where the amount was generally less than the average. The greatest falls appear to have occurred in the Sierras of California, where the amounts for the month ranged from 5 to more than 10 feet at the higher elevations. Heavy snows were also general in Colorado and Wyoming, the maximum depths approaching closely those reported from California.

The snow-covered portions of the United States at the end of the month are shown on Chart VIII. Deep snow covered the interior of New England and portions of northern New York, and the ground was generally well covered in the upper Lake region and from central Iowa and eastern South Dakota northward.

But little snow remained on the ground over the Great Plains region or in the valleys of the mountain districts of the West. In the high mountains, however, there appeared to be an unusual amount of snow and it was generally reported as being in excellent condition to furnish an abundant supply of water until late in the season.

### HUMIDITY AND SUNSHINE.

The relative humidity ranged from 5 to 25 per cent less than the normal over the Great Plains from Kansas southward over Texas and eastern New Mexico, and it was also below the normal by smaller amounts from the above districts eastward to the Atlantic. There were also small areas in the middle and northern Plateau districts with relative humidity below the average.

The relative humidity was unusually high over the upper Missouri Valley and in portions of California and Nevada, and it was generally above the normal from the upper Mississippi Valley eastward to New England, and also in most of the mountain districts of the West.

The month was one of much cloudy weather over the upper Ohio Valley, Lake region, upper Mississippi Valley, and over the northern portion of the Plateau and Pacific coast districts, where generally less than 30 per cent of the possible sunshine was received, and at a few points the amount was less than 20 per cent of the possible.

Over the South Atlantic and east Gulf States and the Florida Peninsula there was ample sunshine, as also over the Great Plains from western Nebraska to Texas and generally over the Southwest.

*In Canada.*—Director R. F. Stupart says:

The mean temperature of February was above the normal in the more southerly portions of all the Provinces and below the normal in the northern portions. This was especially pronounced in Alberta where in the south the positive departure was about 2°, while in the north the negative departure was from 5° to 7°; also in Ontario where in the southwestern counties the positive departure was from 6° to 8°, while in the upper Ottawa Valley the negative departure was 3°. The contrast between south and north was less pronounced in the Maritime Provinces than elsewhere, with the greatest excess of the average 2° at St. John.

The precipitation was considerably in excess of the average in Ontario and over the larger portion of Quebec, while in the Maritime Provinces and also in the West, departures from average were not pronounced in either direction. The most striking feature was probably the large rainfall in the St. Lawrence Valley, heavy rains having occurred on several days. In Ontario and the Maritime Provinces days of rain and snow were nearly equally divided.

At the close of the month the ground was generally snow covered thruout Canada, but the amount varied considerably with the district.

A depth of about 1 inch near the Bay of Fundy increased northward to about 60 inches over the greater portion of Quebec, and in the Cariboo district of British Columbia there was about 40 inches on the ground. In other portions of Canada the depth varied between a trace and 15 inches. Since the beginning of March, however, the Peninsula of Ontario has been covered with snow to a depth of from 3 to 8 inches.

On the 1st of March reports from the Gulf of St. Lawrence showed that the ice was closely packed from Anticosti to the Magdalen Islands, while between the latter place and Cape St. Lawrence there was a heavy open ice field.

*Average temperatures and departures from the normal.*

| Districts. | Number of stations. | Average temperatures for the current month. | Departures for the current month. | Accumulated departures since January 1. | Average departures since January 1. |
|---|---|---|---|---|---|
| | | ° | ° | ° | ° |
| New England | 12 | 28.9 | + 2.9 | + 5.1 | + 2.6 |
| Middle Atlantic | 16 | 40.4 | + 6.1 | +10.1 | + 5.0 |
| South Atlantic | 10 | 52.2 | + 4.2 | + 9.2 | + 4.6 |
| Florida Peninsula* | 8 | 62.4 | + 5.6 | +11.0 | + 5.5 |
| East Gulf | 11 | 53.0 | + 2.1 | + 7.2 | + 3.6 |
| West Gulf | 10 | 53.2 | + 4.0 | + 8.9 | + 4.4 |
| Ohio Valley and Tennessee | 13 | 41.8 | + 5.6 | +10.1 | + 5.0 |
| Lower Lake | 10 | 29.2 | + 4.7 | + 8.9 | + 4.4 |
| Upper Lake | 12 | 22.5 | + 3.5 | + 6.8 | + 3.4 |
| North Dakota* | 9 | 8.8 | + 2.5 | + 1.1 | + 0.6 |
| Upper Mississippi Valley | 15 | 30.2 | + 5.6 | + 9.0 | + 4.5 |
| Missouri Valley | 12 | 29.8 | + 5.4 | + 8.1 | + 4.0 |
| Northern Slope | 9 | 24.3 | + 2.8 | + 2.1 | + 1.0 |
| Middle Slope | 6 | 36.6 | + 4.2 | + 7.7 | + 3.8 |
| Southern Slope* | 7 | 47.1 | + 4.7 | + 9.0 | + 4.5 |
| Southern Plateau* | 12 | 42.7 | — 1.8 | + 3.0 | + 1.5 |
| Middle Plateau* | 10 | 29.2 | + 0.1 | + 6.5 | + 3.2 |
| Northern Plateau* | 12 | 34.8 | + 4.6 | + 2.3 | + 1.2 |
| North Pacific | 7 | 42.0 | + 1.3 | — 3.0 | — 1.5 |
| Middle Pacific | 8 | 49.4 | — 0.2 | + 3.1 | + 1.6 |
| South Pacific | 4 | 52.4 | — 0.2 | + 2.3 | + 1.2 |

* Regular Weather Bureau and selected cooperative stations.

*Average cloudiness and departures from the normal.*

| Districts. | Average. | Departure from the normal. | Districts. | Average. | Departure from the normal. |
|---|---|---|---|---|---|
| New England | 6.2 | + 0.7 | Missouri Valley | 5.2 | — 0.2 |
| Middle Atlantic | 6.2 | + 0.6 | Northern Slope | 5.7 | + 0.9 |
| South Atlantic | 4.2 | — 1.1 | Middle Slope | 4.1 | — 0.3 |
| Florida Peninsula | 3.8 | — 0.8 | Southern Slope | 4.0 | — 0.8 |
| East Gulf | 4.9 | — 0.6 | Southern Plateau | 3.8 | + 0.8 |
| West Gulf | 4.3 | — 1.5 | Middle Plateau | 5.6 | + 0.8 |
| Ohio Valley and Tennessee | 6.3 | + 0.1 | Northern Plateau | 7.8 | + 1.1 |
| Lower Lake | 7.8 | + 1.0 | North Pacific | 8.2 | + 1.2 |
| Upper Lake | 7.6 | + 1.3 | Middle Pacific | 6.6 | + 1.8 |
| North Dakota | 6.4 | + 1.3 | South Pacific | 5.9 | + 1.8 |
| Upper Mississippi Valley | 6.1 | + 0.8 | | | |

*Average precipitation and departures from the normal.*

| Districts. | Number of stations. | Average. | | Departure. | |
|---|---|---|---|---|---|
| | | Current month. | Percentage of normal. | Current month. | Accumulated since Jan. 1. |
| | | *Inches.* | | *Inches.* | *Inches.* |
| New England | 12 | 5.06 | 155 | + 1.8 | + 2.2 |
| Middle Atlantic | 16 | 3.43 | 106 | + 0.2 | − 0.5 |
| South Atlantic | 10 | 3.36 | 83 | − 0.7 | − 2.8 |
| Florida Peninsula* | 8 | 1.27 | 41 | − 1.8 | − 2.6 |
| East Gulf | 11 | 6.11 | 127 | + 1.3 | − 1.8 |
| West Gulf | 10 | 2.12 | 78 | − 0.6 | − 3.2 |
| Ohio Valley and Tennessee | 13 | 6.27 | 173 | + 2.7 | + 1.7 |
| Lower Lake | 10 | 4.16 | 169 | + 1.7 | + 2.0 |
| Upper Lake | 12 | 2.47 | 148 | + 0.8 | + 0.4 |
| North Dakota* | 9 | 0.33 | 62 | − 0.2 | − 0.4 |
| Upper Mississippi Valley | 15 | 2.81 | 164 | + 1.1 | + 1.2 |
| Missouri Valley | 12 | 1.51 | 150 | + 0.5 | + 0.5 |
| Northern Slope | 9 | 0.82 | 100 | 0.0 | 0.0 |
| Middle Slope | 6 | 0.68 | 87 | − 0.1 | − 0.5 |
| Southern Slope* | 7 | 0.33 | 32 | − 0.7 | − 1.6 |
| Southern Plateau* | 12 | 0.93 | 90 | − 0.1 | − 0.1 |
| Middle Plateau* | 10 | 1.25 | 119 | + 0.2 | + 1.2 |
| Northern Plateau* | 12 | 1.43 | 108 | + 0.1 | + 1.2 |
| North Pacific | 7 | 7.45 | 137 | + 2.0 | + 3.8 |
| Middle Pacific | 8 | 7.53 | 192 | + 3.6 | +10.5 |
| South Pacific | 4 | 4.04 | 159 | + 1.5 | + 6.8 |

* Regular Weather Bureau and selected cooperative stations.

*Average relative humidity and departures from the normal.*

| Districts. | Average. | Departure from the normal. | Districts. | Average. | Departure from the normal. |
|---|---|---|---|---|---|
| New England | 74 | − 1 | Missouri Valley | 75 | 0 |
| Middle Atlantic | 73 | − 1 | Northern Slope | 72 | + 1 |
| South Atlantic | 70 | − 6 | Middle Slope | 57 | −10 |
| Florida Peninsula | 78 | − 2 | Southern Slope | 45 | −22 |
| East Gulf | 69 | − 7 | Southern Plateau | 54 | + 7 |
| West Gulf | 68 | − 6 | Middle Plateau | 66 | + 3 |
| Ohio Valley and Tennessee | 74 | 0 | Northern Plateau | 71 | − 5 |
| Lower Lake | 81 | + 1 | North Pacific | 85 | + 4 |
| Upper Lake | 83 | + 1 | Middle Pacific | 84 | + 8 |
| North Dakota | 89 | + 9 | South Pacific | 76 | + 7 |
| Upper Mississippi Valley | 80 | + 3 | | | |

*Maximum wind velocities.*

| Stations. | Date. | Velocity. | Direction. | Stations. | Date. | Velocity. | Direction. |
|---|---|---|---|---|---|---|---|
| Atlanta, Ga | 5 | 52 | w. | New York, N. Y | 10 | 70 | w. |
| Do | 7 | 52 | nw. | Do | 11 | 50 | w. |
| Block Island, R. I | 10 | 52 | s. | Do | 25 | 73 | w. |
| Do | 11 | 53 | w. | Norfolk, Va | 10 | 53 | sw. |
| Do | 20 | 52 | sw. | North Head, Wash | 1 | 54 | se. |
| Do | 25 | 70 | nw. | Do | 4 | 66 | se. |
| Buffalo, N. Y | 1 | 50 | sw. | Do | 5 | 72 | s. |
| Do | 6 | 60 | sw. | Do | 8 | 56 | se. |
| Do | 10 | 66 | sw. | Do | 14 | 76 | se. |
| Do | 11 | 52 | w. | Do | 15 | 72 | se. |
| Do | 17 | 54 | sw. | Do | 16 | 60 | se. |
| Do | 24 | 60 | sw. | Do | 17 | 60 | se. |
| Canton, N. Y | 6 | 72 | w. | Do | 18 | 71 | se. |
| Cleveland, Ohio | 6 | 58 | sw. | Do | 19 | 68 | s. |
| Do | 25 | 52 | w. | Do | 28 | 54 | s. |
| Columbus, Ohio | 24 | 58 | w. | Oklahoma, Okla | 4 | 50 | sw. |
| Detroit, Mich | 10 | 56 | w. | Do | 5 | 54 | n. |
| Duluth, Minn | 9 | 60 | ne. | Pittsburg, Pa | 6 | 54 | w. |
| Do | 10 | 54 | nw. | Point Reyes Light, Cal | 1 | 63 | s. |
| Do | 24 | 54 | nw. | Do | 2 | 75 | s. |
| Eastport, Me | 16 | 50 | ne. | Do | 4 | 56 | s. |
| El Paso, Tex | 4 | 58 | w. | Do | 6 | 52 | s. |
| Do | 8 | 55 | sw. | Do | 7 | 56 | nw. |
| Do | 21 | 57 | sw. | Do | 12 | 68 | s. |
| Fort Smith, Ark | 13 | 52 | nw. | Do | 18 | 52 | nw. |
| Hatteras, N. C | 7 | 51 | nw. | Do | 20 | 78 | nw. |
| Do | 8 | 50 | nw. | Do | 21 | 82 | nw. |
| Do | 25 | 53 | nw. | Do | 23 | 50 | s. |
| Kansas City, Mo | 14 | 52 | ne. | Do | 24 | 53 | s. |
| Lincoln, Nebr | 9 | 58 | nw. | Providence, R. I | 25 | 60 | nw. |
| Little Rock, Ark | 5 | 52 | nw. | Richmond, Va | 10 | 61 | sw. |
| Memphis, Tenn | 5 | 58 | w. | Do | 24 | 50 | s. |
| Milwaukee, Wis | 9 | 55 | e. | Sioux City, Iowa | 9 | 53 | nw. |
| Mount Tamalpais, Cal | 4 | 50 | s. | Southeast Farallon, Cal | 1 | 51 | s. |
| Do | 7 | 50 | sw. | Do | 2 | 62 | s. |
| Do | 11 | 54 | sw. | Do | 11 | 51 | se. |
| Do | 12 | 50 | sw. | Do | 12 | 52 | sw. |
| Do | 19 | 60 | nw. | Do | 20 | 53 | nw. |
| Do | 20 | 58 | nw. | Do | 21 | 64 | nw. |
| Do | 21 | 64 | nw. | Syracuse, N. Y | 6 | 54 | sw. |
| Mount Weather, Va | 1 | 58 | nw. | Tatoosh Island, Wash | 12 | 62 | e. |
| Do | 6 | 52 | nw. | Do | 15 | 54 | e. |
| Do | 20 | 50 | nw. | Do | 18 | 52 | sw. |
| Do | 24 | 53 | nw. | Do | 19 | 60 | sw. |
| Do | 25 | 58 | nw. | Toledo, Ohio | 6 | 57 | sw. |
| Nantucket, Mass | 20 | 53 | sw. | Do | 10 | 50 | sw. |
| New York, N. Y | 6 | 58 | w. | Vicksburg, Miss | 14 | 62 | nw. |

# CLIMATOLOGICAL SUMMARY.

By Mr. P. C. DAY, Acting Chief, Climatological Division.

TEMPERATURE AND PRECIPITATION BY SECTIONS, FEBRUARY, 1909.

In the following table are given, for the various sections of the Climatological Service of the Weather Bureau, the average temperature and rainfall, the stations reporting the highest and lowest temperatures with dates of occurrence, the stations reporting greatest and least monthly precipitation, and other data, as indicated by the several headings.

The mean temperatures for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperature and precipitation are based only on records from stations that have ten or more years of observation. Of course the number of such records is smaller than the total number of stations.

| Section. | Temperature—in degrees Fahrenheit. | | | | | | | | Precipitation—in inches and hundredths. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Section average. | Departure from the normal. | Monthly extremes. | | | | | | Section average. | Departure from the normal. | Greatest monthly. | | Least monthly. | |
| | | | Station. | Highest. | Date. | Station. | Lowest. | Date. | | | Station. | Amount. | Station. | Amount. |
| Alabama | 50.8 | + 4.6 | Livingston | 89 | 23 | Valley Head | 5 | 1 | 7.62 | + 2.03 | Hamilton | 11.53 | Spring Hill | 3.96 |
| Arizona | 46.5 | — 0.2 | Parker | 90 | 26 | Flagstaff | — 6 | 24 | 1.26 | — 0.03 | Chiarsons Mill | 3.59 | 3 stations | 0.00 |
| Arkansas | 47.3 | + 6.5 | Texarkana | 82 | 20 | Pond | 5 | 16 | 5.41 | + 1.86 | Helena No. 2 | 8.96 | Pond | 1.57 |
| California | 46.6 | — 1.0 | Heber | 86 | 19 | Beckwith | — 8 | 9 | 8.00 | + 3.96 | Delta | 28.78 | Calexico | 0.00 |
| Colorado | 26.0 | + 0.7 | Hoehne | 82 | 8, 25 | Kremmling | —31 | 3 | 1.16 | + 0.13 | Corona | 7.32 | Eads | 0.00 |
| Florida | 60.2 | + 0.5 | Brookville<br>Fort Pierce | 90<br>90 | 23<br>24 | Marianna | 18 | 1 | 1.86 | — 1.81 | De Funiak Springs | 5.15 | Miami | T. |
| Georgia | 51.3 | + 4.6 | Alapaha<br>Valdosta | 85 | 23 | Tallapoosa | 8 | 1 | 6.03 | + 0.74 | Diamond | 11.59 | Savannah | 1.33 |
| Hawaii (January) | 67.7 | ....... | Kihei, Maui | 87 | 3 d't's | Humuula, Hawaii | 31 | 3 | 4.52 | ....... | Hakalau, Mauka, Hawaii. | 13.87 | Waiopae Ranch, Maui. | 0.00 |
| Idaho | 31.8 | + 3.1 | Milner | 67 | 3 | Paris | —19 | 1 | 2.38 | + 0.65 | Big Creek | 6.95 | Salmon River Dam. | 0.40 |
| Illinois | 34.3 | + 7.4 | Benton | 71 | 4 | Philo | — 7 | 17 | 4.00 | + 1.64 | Golconda | 9.94 | Zion | 1.25 |
| Indiana | 36.1 | + 7.6 | Farmersburg | 75 | 4 | Bluffton | —13 | 1 | 5.82 | + 2.93 | Rome | 10.04 | Elkhart | 2.81 |
| Iowa | 26.2 | + 7.0 | 4 stations | 62 | 4 | Inwood | —26 | 15 | 1.54 | + 0.48 | Perry | 4.72 | Lenox | 0.30 |
| Kansas | 36.6 | + 6.8 | Ashland | 78 | 28 | Norton | —20 | 15 | 0.79 | — 0.24 | Fort Scott | 2.63 | 4 stations | T |
| Kentucky | 42.4 | + 7.3 | Middlesboro<br>Williamsburg | 75 | 23 | Farmers | — 8 | 1 | 8.16 | + 0.54 | Shelbyville | 11.82 | Williamsburg | 3.70 |
| Louisiana | 54.4 | + 2.5 | St. Francisville | 87 | 12 | Minden | 17 | 1 | 5.02 | — 0.06 | Farriday | 10.12 | Cameron | 2.30 |
| Maryland and Delaware | 41.8 | +10.2 | 3 stations (Del) | 76 | 15, 24 | Deer Park, Md | 4 | 1 | 3.54 | + 0.21 | Bachmans Valley, Md | 7.10 | Solomons, Md | 1.93 |
| Michigan | 24.5 | + 6.2 | Pontiac | 59 | 7 | Ewen | —27 | 28 | 2.73 | + 0.92 | Bay City | 6.25 | Manistee | 0.50 |
| Minnesota | 13.7 | + 2.7 | Worthington | 51 | 3 | International Falls | —48 | 8 | 1.31 | + 0.75 | Fairmount | 3.50 | International Falls.<br>Red Lake | T. |
| Mississippi | 51.2 | + 3.7 | Natchez | 86 | 22 | Corinth<br>Holly Springs | 12 | 1 | 7.13 | + 2.20 | Okolona | 12.86 | Biloxi | 2.99 |
| Missouri | 38.8 | + 7.7 | Dean | 71 | 12 | Louisiana<br>Warrenton | — 4<br>— 4 | 17<br>1 | 3.38 | + 1.09 | New Madrid | 8.87 | Albany | 0.45 |
| Montana | 24.1 | + 2.8 | Clearcreek | 63 | 3 | Jordan | —46 | 14 | 0.66 | — 0.16 | Saltese | 7.25 | 3 stations | 0.00 |
| Nebraska | 28.0 | + 4.0 | Gothenburg | 78 | 3 | Lynch | —28 | 15 | 1.10 | + 0.33 | Springview | 2.40 | 2 stations | 0.09 |
| Nevada | 33.0 | 0.0 | Logan | 73 | 19 | Halleck | — 7 | 6 | 1.29 | 0.00 | Lewers Ranch | 5.95 | Mina | 0.01 |
| New England* | 26.4 | + 3.7 | Monson, Mass. | 61 | 10 | West Ossipee, N. H.<br>Bloomfield, Vt | —30 | 4 | 5.24 | + 2.11 | Colchester, Conn | 8.71 | West Ossipee, N. H. | 1.59 |
| New Jersey | 37.8 | + 8.6 | Indian Mills | 72 | 15 | Charlotteburg<br>Newton | — 2 | 1 | 4.96 | + 1.19 | River Vale | 6.78 | Northfield | 3.55 |
| New Mexico | 38.6 | — 0.6 | Carlsbad<br>Deming | 81<br>81 | 22<br>21 | Winsors | —13 | 23 | 0.44 | — 0.26 | Chama | 2.53 | 4 stations | 0.00 |
| New York | 27.1 | + 6.2 | 5 stations | 58 | 6, 10 | Faust | —34 | 3 | 4.27 | + 1.38 | Lake George | 7.98 | Hemlock Lake | 0.84 |
| North Carolina | 48.6 | + 7.4 | 4 stations | 80 | 3 d't's | Banners Elk | — 3 | 1 | 4.20 | — 0.55 | Lake Toxaway | 11.12 | Pittsboro | 2.08 |
| North Dakota | 9.6 | + 2.7 | Beach | 56 | 3 | Coal Harbor | —34 | 10 | 0.34 | — 0.14 | Bottineau | 1.08 | 3 stations | 0.00 |
| Ohio | 34.7 | + 8.3 | Ironton | 70 | 23 | Grangeville | —17 | 1 | 5.39 | + 2.79 | Lawshe | 9.91 | Cleveland | 3.22 |
| Oklahoma | 44.3 | + 6.6 | Pauls Valley<br>Erick | 84<br>84 | 12<br>26 | Eldorado | — 2 | 15 | 0.67 | — 0.46 | Idabel | 3.35 | Alva | 0.00 |
| Oregon | 39.9 | + 2.1 | Ellen | 73 | 3 | Christmas Lake<br>Granite | — 4<br>— 4 | 8<br>11 | 6.49 | + 1.89 | Glenora | 28.77 | Paisley | 0.55 |
| Pennsylvania | 35.8 | + 9.0 | Hanover | 73 | 16 | Saegerstown | — 9 | 1 | 4.84 | + 1.82 | Hamburg | 9.86 | Lawrenceville | 2.40 |
| Porto Rico | 73.0 | — 1.0 | Añasco | 92 | 1, 4, 5 | Cayey | 48 | 26 | 4.51 | + 2.28 | Comerio Falls | 12.35 | Guanica Centrale | 0.00 |
| South Carolina | 52.2 | + 6.2 | Blackville<br>Bowman | 84<br>84 | 22<br>23 | Liberty<br>St. Matthews | 12 | 1 | 4.49 | — 0.14 | Calhoun Falls | 7.42 | Charleston | 1.86 |
| South Dakota | 19.8 | + 3.8 | Rapid City | 69 | 3 | Kidder | —29 | 9 | 0.97 | + 0.60 | Menno | 2.76 | Fort Meade | 0.12 |
| Tennessee | 46.2 | + 6.7 | Sevierville | 81 | 23 | Mountain City | — 4 | 1 | 6.99 | + 2.81 | Hohenwald | 10.23 | Bluff City | 2.70 |
| Texas | 54.1 | + 4.1 | Falfurrias | 98 | 22 | Canadian<br>Texline | 1 | 14 | 0.90 | — 1.09 | Lufkin | 4.65 | 11 stations | 0.00 |
| Utah | 29.5 | — 0.9 | Experiment Farm | 67 | 2 | Scofield | —32 | 24 | 2.15 | + 0.99 | Park City | 10.53 | Green River | 0.23 |
| Virginia | 44.1 | + 9.0 | Norfolk (near) | 80 | 24 | Burkes Garden | — 1 | 1 | 3.25 | — 0.24 | Big Stone Gap | 5.86 | Shenandoah | 1.93 |
| Washington | 37.9 | + 2.0 | Kiona | 66 | 2, 3 | Conconully<br>Republic | — 5 | 12 | 5.37 | + 0.82 | Quiniault | 27.11 | Kennewick | 0.45 |
| West Virginia | 40.4 | + 9.9 | Logan | 80 | 23 | Cuba | — 5 | 1 | 4.16 | + 1.10 | Terra Alta | 7.68 | Upper Tract | 1.44 |
| Wisconsin | 21.3 | + 6.0 | Prairie du Chien | 53 | 5 | Osceola | —29 | 25 | 1.54 | + 0.41 | Oconto | 3.20 | Grand River Locks. | 0.52 |
| Wyoming | 22.6 | + 1.5 | Pine Bluff | 68 | 3 | Eden | —33 | 23 | 1.12 | + 0.18 | Snake River, Y.N.P. | 4.60 | Powell | T. |

* Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut.

# DESCRIPTION OF TABLES AND CHARTS.

By Mr. P. C. DAY, Acting Chief, Climatological Division.

For description of tables and charts see page 34 of REVIEW for January, 1909.

TABLE I.—*Climatological data for U. S. Weather Bureau stations, February, 1909.*

| Stations. | Elevation of instruments: Barometer above sea level, feet. | Thermometers above ground. | Anemometer above ground. | Pressure, in inches: Actual, reduced to mean of 24 hours. | Sea level, reduced to mean of 24 hrs. | Departure from normal. | Temperature of the air, in degrees Fahrenheit: Mean max. + mean min. ÷ 2. | Departure from normal. | Maximum. | Date. | Mean maximum. | Minimum. | Date. | Mean minimum. | Greatest daily range. | Mean wet thermometer. | Mean temperature of the dew-point. | Mean relative humidity, per cent. | Precipitation, in inches: Total. | Departure from normal. | Days with .01, or more. | Wind: Total movement, miles. | Prevailing direction. | Maximum velocity: Miles per hour. | Direction. | Date. | Clear days. | Partly cloudy days. | Cloudy days. | Average cloudiness during daylight, tenths. | Total snowfall. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *New England.* | | | | | | | 28.9 | + 2.9 | | | | | | | | | | 74 | 5.06 | + 1.3 | | | | | | | | | | 6.2 | |
| Eastport | 76 | 67 | 85 | 29.78 | 29.87 | — .11 | 22.2 | + 0.8 | 47 | 10 | 31 | — 4 | 2 | 14 | 39 | 20 | 16 | 79 | 4.76 | + 1.1 | 9 | 10,824 | w. | 50 | ne. | 16 | 7 | 5 | 16 | 6.8 | 16.0 |
| Greenville | 1,070 | 6 | .... | 28.67 | 29.89 | | 14.7 | | 43 | 20 | 26 | —20 | 19 | 3 | 44 | .... | .... | .... | 4.80 | .... | 10 | .... | se. | .... | .... | .... | .... | .... | .... | .... | |
| Portland, Me. | 103 | 81 | 117 | 29.79 | 29.92 | — .10 | 25.2 | + 1.4 | 50 | 13 | 33 | 1 | 1 | 17 | 31 | 22 | 17 | 73 | 5.07 | + 1.4 | 10 | 6,955 | nw. | 46 | s. | 10 | 11 | 7 | 10 | 5.0 | 14.3 |
| Concord | 288 | 70 | 79 | 29.61 | 29.94 | — .10 | 25.4 | + 1.8 | 53 | 5 | 35 | —14 | 4 | 16 | 44 | .... | .... | .... | 3.25 | 0.0 | 10 | 4,229 | nw. | 35 | w. | 6 | 13 | 6 | 9 | 4.9 | 4.1 |
| Burlington | 404 | 12 | 47 | 29.47 | 29.94 | — .09 | 20.0 | + 2.1 | 48 | 6 | 30 | —14 | 1 | 10 | 32 | .... | .... | .... | 4.18 | + 2.8 | 13 | 8,827 | s. | 48 | w. | 6 | 9 | 5 | 14 | 6.2 | 19.5 |
| Northfield | 876 | 16 | 70 | 28.95 | 29.94 | — .10 | 19.2 | + 2.0 | 52 | 5 | 30 | —17 | 4 | 8 | 44 | 16 | 13 | 82 | 4.85 | + 2.6 | 14 | 6,056 | n. | 36 | nw. | 6 | 8 | 6 | 14 | 6.6 | 12.7 |
| Boston | 125 | 115 | 188 | 29.79 | 29.93 | — .11 | 32.6 | + 4.6 | 59 | 5 | 41 | 3 | 1 | 25 | 32 | 29 | 22 | 67 | 4.71 | + 1.3 | 10 | 8,575 | w. | 43 | sw. | 10 | 8 | 9 | 11 | 6.1 | 2.3 |
| Nantucket | 12 | 14 | 90 | 29.91 | 29.92 | — .12 | 35.4 | + 2.8 | 52 | 24 | 41 | 15 | ·2 | 29 | 25 | 33 | 29 | 79 | 4.88 | + 1.8 | 10 | 13,134 | w. | 53 | sw. | 20 | 3 | 15 | 10 | 6.9 | T. |
| Block Island | 26 | 11 | 46 | 29.90 | 29.94 | — .12 | 35.0 | + 3.8 | 54 | 10 | 40 | 8 | 1 | 30 | 28 | 32 | 28 | 78 | 5.70 | + 1.4 | 11 | 15,214 | w. | 70 | nw. | 25 | 8 | 5 | 15 | 6.6 | T. |
| Narragansett | .... | 9 | | | | | 32.8 | + 4.5 | 60 | 20 | 41 | 3 | 1 | 21 | 28 | .... | .... | .... | 6.68 | .... | 11 | .... | sw. | .... | .... | .. | 13 | 8 | 7 | .... | T. |
| Providence | 160 | 141 | 165 | 29.78 | 29.96 | — .09 | 32.8 | + 3.8 | 58 | 10 | 41 | 3 | 1 | 24 | 34 | 29 | 23 | 70 | 5.80 | + 2.4 | 13 | 8,539 | nw. | 60 | nw. | 25 | 7 | 12 | 9 | 5.9 | 3.2 |
| Hartford | 159 | 122 | 140 | 29.77 | 29.96 | — .10 | 32.2 | + 5.0 | 56 | 6 | 40 | 1 | 1 | 24 | 34 | 28 | 23 | 72 | 5.47 | + 1.9 | 16 | 6,064 | nw. | 42 | s. | 10 | 4 | 11 | 13 | 7.0 | 1.6 |
| New Haven | 106 | 116 | 155 | 29.82 | 29.95 | — .12 | 34.3 | + 6.0 | 56 | 6 | 42 | 1 | 1 | 27 | 28 | 30 | 24 | 70 | 6.98 | + 3.2 | 12 | 6,629 | ne. | 44 | nw. | 25 | 6 | 14 | 8 | 5.9 | 1.2 |
| *Mid. Atlantic States.* | | | | | | | 40.4 | + 6.1 | | | | | | | | | | 73 | 3.43 | + 0.2 | | | | | | | | | | 6.2 | |
| Albany | 97 | 102 | 115 | 29.85 | 29.96 | — .11 | 28.4 | + 4.8 | 51 | 6 | 37 | — 6 | 1 | 20 | 31 | 25 | 21 | 77 | 4.00 | + 1.5 | 13 | 5,747 | nw. | 33 | se. | 6 | 5 | 13 | 10 | 6.5 | 7.1 |
| Binghamton | 871 | 78 | 90 | 28.98 | 29.93 | — .15 | 31.2 | + 6.5 | 55 | 5 | 39 | — 1 | 1 | 23 | 31 | .... | .... | .... | 2.96 | + 1.1 | 15 | 5,487 | w. | 35 | sw. | 10 | 1 | 7 | 20 | 8.5 | 1.3 |
| New York | 314 | 108 | 350 | 29.60 | 29.95 | — .13 | 37.3 | + 6.6 | 58 | 10 | 44 | 5 | 1 | 31 | 25 | 34 | 29 | 74 | 4.31 | + 0.6 | 12 | 11,012 | w. | 73 | w. | 25 | 3 | 11 | 14 | 6.8 | 1.4 |
| Harrisburg | 374 | 94 | 104 | 29.55 | 29.96 | — .13 | 38.1 | + 8.2 | 67 | 16 | 46 | 11 | 1 | 30 | 31 | 34 | 28 | 72 | 4.13 | + 1.4 | 13 | 6,403 | w. | 42 | w. | 6 | 4 | 9 | 15 | 7.0 | 2.3 |
| Philadelphia | 117 | 116 | 184 | 29.86 | 29.99 | — .11 | 41.2 | + 8.4 | 67 | 15 | 49 | 12 | 1 | 34 | 26 | 37 | 31 | 70 | 4.62 | + 1.2 | 13 | 8,069 | nw. | 38 | nw. | 25 | 6 | 10 | 12 | 6.5 | 2.2 |
| Scranton | 805 | 111 | 119 | 29.06 | 29.95 | — .31 | 34.2 | + 7.3 | 58 | 24 | 42 | 3 | 1 | 26 | 30 | 30 | 25 | 71 | 4.16 | + 1.4 | 15 | 6,148 | sw. | 41 | sw. | 6 | 1 | 8 | 19 | 8.4 | 2.7 |
| Atlantic City | 52 | 37 | 48 | 29.92 | 29.98 | — .13 | 39.7 | + 6.7 | 61 | 6 | 46 | 11 | 1 | 33 | 25 | 36 | 32 | 76 | 3.75 | + 0.5 | 13 | 6,835 | nw. | 37 | se. | 19 | 7 | 10 | 11 | 6.4 | 3.8 |
| Cape May | 17 | 48 | 52 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Baltimore | 123 | 100 | 113 | 29.85 | 29.98 | — .13 | 42.6 | + 8.0 | 70 | 16 | 51 | 17 | 1 | 34 | 32 | 38 | 32 | 70 | 3.25 | — 0.3 | 10 | 5,445 | sw. | 36 | sw. | 6 | 6 | 7 | 15 | 6.6 | 3.3 |
| Washington | 112 | 59 | 76 | 29.86 | 29.98 | — .13 | 43.0 | + 8.5 | 70 | 16 | 52 | 17 | 1 | 34 | 32 | 38 | 32 | 71 | 3.11 | — 0.3 | 10 | 5,904 | nw. | 46 | sw. | 12 | 8 | 12 | 8 | 5.4 | 6.4 |
| Cape Henry | 18 | 9 | 58 | 29.98 | 30.00 | — .11 | 48.8 | + 7.6 | 78 | 24 | 58 | 24 | 1 | 40 | 30 | .... | .... | .... | 2.56 | — 1.2 | 10 | 10,764 | sw. | 46 | nw. | 8 | 13 | 8 | 7 | 4.5 | T. |
| Lynchburg | 681 | 83 | 88 | 29.26 | 30.02 | — .09 | 45.2 | + 7.0 | 70 | 16 | 55 | 17 | 1 | 35 | 31 | 40 | 35 | 71 | 3.09 | — 0.4 | 14 | 4,161 | nw. | 27 | nw. | 25 | 12 | 5 | 11 | 5.5 | 1.8 |
| Mount Weather | 1,725 | 10 | 54 | 28.09 | 29.96 | — .15 | 38.2 | + 9.1 | 61 | 16 | 46 | 9 | 1 | 31 | 28 | 34 | 30 | 75 | 3.42 | + 0.3 | 10 | 12,617 | nw. | 58 | nw. | 25 | 5 | 12 | 11 | 6.4 | 8.8 |
| Norfolk | 91 | 102 | 111 | 29.93 | 30.03 | — .08 | 50.3 | + 8.5 | 78 | 24 | 59 | 22 | 1 | 42 | 25 | 14 | 38 | 70 | 2.99 | — 0.8 | 10 | 8,447 | s. | 53 | sw. | 10 | 11 | 8 | 9 | 5.1 | T. |
| Richmond | 144 | 145 | 153 | 29.88 | 30.03 | — .08 | 47.5 | + 7.5 | 73 | 24 | 58 | 18 | 1 | 37 | 34 | .... | .... | .... | 2.94 | — 0.2 | 11 | 8,021 | s. | 61 | sw. | 10 | 10 | 10 | 8 | 5.1 | 4.1 |
| Wytheville | 2,293 | 40 | 47 | 27.59 | 30.02 | — .10 | 40.7 | + 5.6 | 66 | 23 | 51 | 7 | 1 | 31 | 39 | 36 | 32 | 78 | 2.21 | — 1.9 | 13 | 6,113 | w. | 32 | nw. | 24 | 14 | 3 | 11 | 4.6 | 3.3 |
| *S. Atlantic States.* | | | | | | | 52.2 | + 4.2 | | | | | | | | | | 70 | 3.36 | — 0.7 | | | | | | | | | | 4.2 | |
| Asheville | 2,255 | 53 | 75 | 27.65 | 30.06 | — .07 | 43.0 | + 4.5 | 68 | 21 | 54 | 4 | 1 | 32 | 39 | 38 | 34 | 77 | 3.60 | — 1.0 | 12 | 7,327 | se. | 36 | se. | 25 | 15 | 3 | 10 | 4.7 | 0.3 |
| Charlotte | 773 | 68 | 76 | 29.21 | 30.06 | — .06 | 48.9 | + 4.8 | 72 | 15 | 59 | 16 | 1 | 39 | 29 | 42 | 36 | 66 | 3.64 | — 0.8 | 15 | 6,832 | sw. | 36 | sw. | 10 | 8 | 10 | 10 | 5.2 | |
| Hatteras | 11 | 12 | 47 | 30.05 | 30.06 | — .05 | 52.6 | + 6.0 | 69 | 14 | 59 | 28 | 1 | 46 | 20 | 49 | 47 | 85 | 3.40 | — 1.1 | 10 | 11,832 | sw. | 53 | nw. | 25 | 17 | 7 | 4 | 3.6 | |
| Manteo | .... | .... | .... | .... | .... | .... | 51.0 | .... | 71 | 24 | 60 | 24 | 1 | 42 | .... | .... | .... | .... | 4.31 | + 0.1 | 9 | ...... | sw. | .... | .... | .. | 18 | 3 | 7 | .... | |
| Raleigh | 376 | 71 | 79 | 29.64 | 30.05 | — .06 | 49.9 | + 6.6 | 73 | 15 | 60 | 18 | 1 | 39 | 29 | 42 | 34 | 60 | 3.14 | — 1.2 | 12 | 7,097 | sw. | 46 | sw. | 10 | 12 | 9 | 7 | 4.7 | |
| Wilmington | 78 | 81 | 91 | 30.01 | 30.10 | — .02 | 53.1 | + 5.4 | 73 | 6 | 63 | 20 | 1 | 41 | 30 | 46 | 40 | 69 | 3.30 | — 0.1 | 7 | 6,952 | sw. | 40 | sw. | 24 | 14 | 8 | 6 | 4.0 | |
| Charleston | 48 | 14 | 92 | 30.06 | 30.11 | — .01 | 55.0 | + 3.3 | 75 | 23 | 64 | 24 | 1 | 46 | 27 | 48 | 43 | 72 | 1.86 | — 1.6 | 8 | 7,470 | sw. | 37 | s. | 6 | 12 | 10 | 6 | 4.1 | |
| Columbia, S. C. | 351 | 41 | 57 | 29.69 | 30.08 | — .03 | 52.8 | + 5.0 | 78 | 23 | 64 | 17 | 1 | 42 | 32 | 44 | 35 | 59 | 4.42 | — 0.2 | 10 | 6,504 | w. | 40 | w. | 19 | 11 | 9 | 8 | 4.9 | |
| Augusta | 180 | 89 | 97 | 29.90 | 30.09 | — .03 | 53.0 | + 4.0 | 81 | 23 | 64 | 18 | 1 | 42 | 35 | 45 | 39 | 65 | 6.49 | + 2.1 | 11 | 5,455 | w. | 36 | w. | 7 | 16 | 5 | 7 | 4.1 | |
| Savannah | 65 | 81 | 89 | 30.06 | 30.12 | .00 | 56.0 | + 3.5 | 77 | 22 | 66 | 24 | 1 | 46 | 28 | 48 | 42 | 67 | 1.33 | — 2.0 | 6 | 6,327 | sw. | 31 | w. | 7 | 12 | 12 | 4 | 3.8 | |
| Jacksonville | 43 | 101 | 129 | 30.10 | 30.15 | + .03 | 58.2 | + 1.3 | 81 | 23 | 68 | 25 | 1 | 48 | 28 | 52 | 49 | 78 | 1.51 | — 1.9 | 7 | 6,580 | s. | 49 | sw. | 19 | 15 | 11 | 2 | 3.3 | |
| *Florida Peninsula.* | | | | | | | 66.2 | + 0.2 | | | | | | | | | | 78 | 0.61 | — 1.8 | | | | | | | | | | 3.8 | |
| Jupiter | 28 | 10 | 48 | 30.11 | 30.14 | + .06 | 66.6 | + 0.3 | 83 | 19 | 74 | 34 | 1 | 59 | 28 | 61 | 58 | 77 | 0.41 | — 2.6 | 4 | 8,924 | s. | 36 | se. | 15 | 4 | 23 | 1 | 4.9 | |
| Key West | 22 | 10 | 53 | 30.09 | 30.11 | + .04 | 70.3 | — 0.5 | 81 | 22 | 76 | 47 | 1 | 65 | 18 | 65 | 63 | 84 | 0.10 | — 1.5 | 3 | 6,923 | ne. | 26 | e. | 12 | 18 | 9 | 1 | 3.0 | |
| Sand Key | 25 | 41 | 71 | 30.08 | 30.10 | + .03 | 69.5 | ...... | 76 | 10 | 72 | 50 | 1 | 67 | 10 | .... | .... | .... | 0.91 | — 0.7 | 4 | 12,542 | ne. | 39 | nw. | 24 | 15 | 13 | 0 | 3.6 | |
| Tampa | 35 | 79 | 96 | 30.11 | 30.15 | + .05 | 61.6 | + 0.7 | 83 | 22 | 72 | 27 | 1 | 51 | 28 | 54 | 50 | 74 | 1.01 | — 2.3 | 6 | 5,873 | nw. | 32 | sw. | 24 | 13 | 10 | 5 | 3.8 | |
| *East Gulf States.* | | | | | | | 53.0 | + 2.1 | | | | | | | | | | 69 | 6.11 | + 1.3 | | | | | | | | | | 4.9 | |
| Atlanta | 1,174 | 190 | 216 | 28.83 | 30.09 | — .03 | 49.2 | + 4.0 | 76 | 23 | 59 | 14 | 1 | 40 | 34 | 42 | 35 | 67 | 8.07 | + 3.4 | 10 | 10,356 | w. | 52 | nw. | 7 | 13 | 4 | 11 | 4.8 | |
| Macon | 370 | 78 | 87 | 29.71 | 30.11 | — .01 | 52.6 | + 3.7 | 81 | 23 | 64 | 18 | 1 | 41 | 37 | .... | .... | .... | 6.70 | + 2.1 | 10 | 5,375 | s. | 32 | s. | 9 | 14 | 5 | 9 | 4.4 | |
| Thomasville | 273 | 8 | 58 | 29.84 | 30.14 | + .02 | 55.3 | + 0.3 | 80 | 23 | 68 | 21 | 1 | 42 | 39 | 46 | 41 | 71 | 2.31 | — 2.1 | 7 | 4,606 | s. | 30 | s. | 15 | 14 | 9 | 5 | 3.6 | |
| Pensacola | 56 | 79 | 96 | 30.07 | 30.13 | + .02 | 56.2 | + 0.7 | 73 | 22 | 64 | 25 | 1 | 49 | 25 | .... | .... | .... | 4.40 | — 0.1 | 8 | 8,172 | se. | 49 | sw. | 19 | 12 | 5 | 11 | 4.9 | |
| Anniston | 741 | 9 | 58 | 29.30 | 30.11 | — .01 | 49.4 | + 3.6 | 75 | 23 | 60 | 15 | 1 | 38 | 35 | .... | .... | .... | 8.25 | + 3.6 | 12 | 5,504 | se. | 31 | w. | 5 | 11 | 4 | 13 | 5.4 | |
| Birmingham | 700 | 11 | 48 | 29.31 | 30.09 | — .03 | 50.8 | + 2.5 | 77 | 23 | 60 | 15 | 1 | 42 | 29 | 45 | 39 | 70 | 7.10 | + 2.4 | 11 | 7,080 | s. | 40 | s. | 23 | 11 | 7 | 10 | 4.9 | |
| Mobile | 57 | 98 | 106 | 30.04 | 30.11 | .00 | 51.8 | + 1.6 | 73 | 23 | 64 | 24 | 1 | 46 | 26 | 49 | 45 | 74 | 4.08 | — 1.3 | 9 | 6,387 | se. | 46 | sw. | 5 | 12 | 9 | 7 | 4.9 | |
| Montgomery | 223 | 100 | 112 | 29.85 | 30.11 | — .01 | 52.6 | + 1.3 | 78 | 23 | 63 | 20 | 1 | 42 | 36 | 46 | 39 | 65 | 9.05 | + 3.5 | 10 | 5,639 | s. | 34 | sw. | 5 | 11 | 5 | 12 | 5.4 | |
| Meridian | 375 | 84 | 93 | 29.68 | 30.08 | — .03 | 51.6 | + 2.5 | 81 | 22 | 63 | 18 | 1 | 41 | 37 | 45 | 40 | 70 | 4.40 | — 0.5 | 11 | 5,084 | s. | 30 | sw. | 14 | 9 | 9 | 10 | 5.1 | |
| Vicksburg | 247 | 62 | 74 | 29.78 | 30.07 | — .03 | 53.5 | + 2.6 | 81 | 22 | 64 | 23 | 1 | 44 | 29 | 46 | 39 | 63 | 7.20 | + 2.6 | 9 | 6,335 | se. | 62 | nw. | 14 | 8 | 8 | 12 | 5.5 | T. |
| New Orleans | 51 | 90 | 121 | 30.04 | 30.10 | + .01 | 57.1 | + 0.8 | 79 | 13 | 66 | 28 | 1 | 48 | 25 | 51 | 46 | 74 | 5.61 | + 1.1 | 6 | 7,472 | se. | 45 | se. | 14 | 10 | 9 | 9 | 5.8 | |
| *West Gulf States.* | | | | | | | 53.2 | + 4.0 | | | | | | | | | | 68 | 2.12 | — 0.6 | | | | | | | | | | 4.3 | |
| Shreveport | 249 | 77 | 84 | 29.76 | 30.04 | — .05 | 53.2 | + 3.2 | 80 | 20 | 64 | 21 | 16 | 42 | 47 | 48 | 44 | 76 | 3.90 | + 0.3 | 7 | 6,256 | se. | 37 | w. | 5 | 13 | 8 | 7 | 4.7 | 0.8 |
| Bentonville | 1,303 | 11 | 44 | 28.58 | 29.97 | — .13 | 42.4 | + 3.9 | 70 | 12 | 54 | 11 | 16 | 30 | 44 | .... | .... | .... | 1.99 | — 0.5 | 9 | 5,749 | s. | 34 | w. | 13 | 16 | 2 | 10 | 4.5 | 1.9 |
| Fort Smith | 457 | 79 | 94 | 29.48 | 29.98 | — .12 | 46.6 | + 4.8 | 77 | 12 | 58 | 16 | 16 | 35 | 40 | 39 | 31 | 62 | 2.84 | + 0.1 | 8 | 5,862 | e. | 52 | nw. | 13 | 16 | 7 | 5 | 3.8 | 2.5 |
| Little Rock | 357 | 139 | 147 | 29.62 | 30.00 | — .11 | 49.4 | + 5.3 | 74 | 22 | 60 | 19 | 16 | 39 | 31 | 42 | 35 | 63 | 5.18 | + 1.0 | 8 | 7,819 | nw. | 52 | nw. | 5 | 12 | 8 | 8 | 4.4 | T. |
| Brownsville | 57 | 4 | ... | ...... | ...... | ...... | ...... | ...... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | ...... | ...... | .... | ...... | ...... | .... | ...... | ... | ... | ... | ... | .... | |
| Corpus Christi | 20 | 69 | 77 | 30.02 | 30.04 | — .01 | 61.6 | + 3.9 | 85 | 22 | 69 | 27 | 15 | 54 | 35 | 55 | 49 | 70 | 0.47 | — 1.6 | 5 | 10,631 | s. | 42 | s. | 13 | 13 | 9 | 6 | 4.4 | |
| Fort Worth | 670 | 106 | 114 | 29.29 | 30.02 | — .05 | 53.8 | + 5.7 | 83 | 12 | 67 | 15 | 15 | 41 | 50 | .... | .... | .... | 0.11 | — 1.2 | 2 | 9,491 | s. | 44 | w. | 18 | 16 | 10 | 2 | 3.2 | T. |
| Galveston | 54 | 106 | 112 | 30.02 | 30.08 | + .01 | 57.1 | + 1.5 | 74 | 5 | 63 | 24 | 15 | 51 | 38 | 54 | 51 | 83 | 1.46 | — 1.6 | 6 | 8,932 | se. | 44 | nw. | 24 | 12 | 7 | 9 | 4.7 | |
| Palestine | 510 | 73 | 79 | 29.49 | 30.03 | — .05 | 54.0 | + 3.1 | 81 | 12 | 65 | 18 | 15 | 43 | 43 | 47 | 42 | 69 | 3.56 | + 0.2 | 8 | 7,203 | s. | 36 | w. | 5 | 11 | 4 | 13 | 5.3 | 0.2 |
| San Antonio | 701 | 80 | 91 | 29.29 | 30.02 | — .03 | 58.4 | + 0.4 | 88 | 22 | 70 | 21 | 15 | 47 | 40 | 49 | 38 | 56 | 0.71 | — 1.1 | 2 | 5,378 | se. | 35 | n. | 14 | 13 | 7 | 8 | 4.5 | |
| Taylor | 583 | 55 | 63 | 29.43 | 30.04 | — .02 | 55.2 | + 3.9 | 84 | 22 | 68 | 19 | 15 | 42 | 38 | .... | .... | .... | 0.96 | — 1.6 | 4 | 7,401 | s. | 45 | nw. | 14 | 15 | 8 | 5 | 3.4 | |
| *Ohio Val. and Tenn.* | | | | | | | 41.8 | + 5.6 | | | | | | | | | | 74 | 6.27 | + 2.7 | | | | | | | | | | 6.3 | |
| Chattanooga | 762 | 106 | 112 | 29.25 | 30.08 | — .05 | 48.5 | + 4.8 | 74 | 23 | 58 | 15 | 1 | 39 | 32 | 42 | 35 | 66 | 7.06 | + 2.1 | 12 | 5,436 | s. | 41 | sw. | 5 | 12 | 3 | 13 | 5.3 | 0.1 |
| Knoxville | 1,004 | 93 | 100 | 28.98 | 30.05 | — .07 | 46.1 | + 5.3 | 76 | 23 | 57 | 11 | 1 | 35 | 38 | 40 | 34 | 71 | 7.05 | + 2.2 | 12 | 4,549 | sw. | 42 | sw. | 9 | 12 | 4 | 12 | 5.3 | T. |
| Memphis | 399 | 76 | 97 | 29.60 | 30.03 | — .08 | 48.6 | + 5.3 | 75 | 22 | 57 | 18 | 1 | 40 | 27 | 43 | 36 | 64 | 7.75 | + 3.4 | 12 | 7,921 | s. | 58 | w. | 5 | 9 | 8 | 11 | 5.4 | T. |
| Nashville | 546 | 79 | 91 | 29.44 | 30.03 | — .09 | 46.8 | + 5.7 | 71 | 21 | 56 | 12 | 1 | 37 | 36 | 42 | 39 | 76 | 7.08 | + 2.8 | 11 | 5,880 | sw. | 36 | s. | 12 | 7 | 6 | 15 | 6.4 | 0.1 |
| Lexington | 989 | 75 | 102 | 28.91 | 30.00 | — .11 | 41.0 | + 5.4 | 68 | 23 | 50 | 6 | 1 | 32 | 38 | .... | .... | .... | 6.86 | + 3.6 | 13 | 9,652 | sw. | 38 | w. | 24 | 9 | 4 | 15 | 6.1 | 2.4 |
| Louisville | 525 | 111 | 182 | 29.40 | 29.99 | — .12 | 42.0 | + 5.4 | 65 | 23 | 51 | 10 | 1 | 33 | 34 | 38 | 33 | 72 | 9.64 | + 5.9 | 11 | 6,836 | w. | 38 | w. | 24 | 9 | 4 | 15 | 6.5 | 3.0 |
| Evansville | 431 | 72 | 82 | 29.49 | 29.97 | — .14 | 41.4 | + 5.6 | 64 | 23 | 50 | 12 | 1 | 33 | 29 | .... | .... | .... | 7.04 | + 4.0 | 12 | 6,772 | s. | 36 | sw. | 23 | 4 | 15 | 9 | 6.0 | 2.4 |
| Indianapolis | 822 | 154 | 164 | 29.04 | 29.95 | — .15 | 35.5 | + 4.8 | 62 | 23 | 44 | 13 | 1 | 28 | 30 | 33 | 29 | 80 | 4.65 | + 1.6 | 16 | 8,411 | sw. | 43 | sw. | 10 | 5 | 12 | 11 | 6.9 | 1.0 |
| Cincinnati | 628 | 152 | 160 | 29.28 | 29.97 | — .13 | 40.1 | + 5.7 | 64 | 14 | 49 | 9 | 1 | 32 | 38 | 36 | 30 | 70 | 5.65 | + 2.4 | 12 | 5,739 | se. | 23 | w. | 24 | 6 | 6 | 16 | 6.9 | 2.7 |
| Columbus | 824 | 173 | 224 | 29.06 | 29.96 | — .13 | 36.2 | + 5.2 | 61 | 24 | 45 | 0 | 1 | 28 | 38 | 32 | 29 | 80 | 4.97 | + 1.9 | 12 | 9,918 | sw. | 58 | w. | 24 | 5 | 8 | 15 | 6.8 | 1.3 |
| Pittsburg | 842 | 336 | 352 | 29.04 | 29.96 | — .13 | 37.3 | + 5.5 | 64 | 24 | 46 | 8 | 1 | 29 | 36 | 33 | 30 | 76 | 4.47 | + 1.8 | 16 | 8,789 | w. | 54 | w. | 6 | 4 | 7 | 17 | 7.4 | 0.5 |
| Parkersburg | 638 | 77 | 84 | 29.32 | 29.99 | — .11 | 40.8 | + 6.9 | 65 | 14 | 50 | 7 | 1 | 31 | 33 | 37 | 34 | 84 | 6.14 | + 2.9 | 14 | 5,507 | s. | 40 | nw. | 24 | 6 | 7 | 15 | 6.9 | 1.6 |
| Elkins | 1,940 | 41 | 50 | 27.91 | 30.02 | — .08 | 38.8 | + 7.3 | 71 | 15 | 49 | 9 | 1 | 28 | 39 | 34 | 30 | 79 | 3.20 | 0.0 | 20 | 4,380 | w. | 30 | nw. | 24 | 8 | 7 | 13 | 6.4 | 5.7 |
| *Lower Lake Region.* | | | | | | | 29.2 | + 4.7 | | | | | | | | | | 81 | 4.16 | + 1.7 | | | | | | | | | | 7.5 | |
| Buffalo | 767 | 178 | 206 | 29.06 | 29.91 | — .15 | 29.6 | + 5.6 | 55 | 5 | 37 | — 1 | 1 | 22 | 28 | 27 | 24 | 82 | 3.70 | + 0.8 | 21 | 12,831 | w. | 66 | sw. | 10 | 2 | 7 | 19 | 8.0 | 9.2 |
| Canton | 448 | 10 | 71 | 29.42 | 29.93 | ....... | 20.4 | + 2.4 | 54 | 6 | 31 | —15 | 1 | 10 | 38 | .... | .... | .... | 3.82 | + 1.2 | 16 | 9,784 | sw. | 72 | w. | 6 | 3 | 11 | 14 | 7.1 | 18.1 |
| Oswego | 335 | 76 | 91 | 29.54 | 29.92 | — .14 | 27.2 | + 3.3 | 53 | 6 | 34 | — 7 | 1 | 20 | 31 | 25 | 22 | 84 | 3.85 | + 1.3 | 16 | 9,701 | s. | 42 | nw. | 6 | 1 | 3 | 24 | 8.8 | 7.8 |
| Rochester | 523 | 81 | 102 | 29.34 | 29.93 | — .13 | 29.2 | + 5.3 | 54 | 6 | 36 | 3 | 1 | 22 | 33 | 26 | 22 | 77 | 2.90 | + 0.1 | 16 | 7,510 | w. | 48 | sw. | 6 | 2 | 7 | 19 | 8.4 | 6.1 |
| Syracuse | 597 | 97 | 113 | 29.26 | 29.92 | — .15 | 20.2 | + 5.4 | 54 | 5 | 37 | — 8 | 1 | 21 | 34 | .... | .... | .... | 4.55 | + 2.8 | 20 | 9,473 | w. | 54 | sw. | 6 | 1 | 5 | 22 | 8.5 | 10.6 |
| Erie | 713 | 92 | 102 | 29.13 | 29.92 | — .15 | 31.2 | + 5.1 | 61 | 24 | 38 | 8 | 1 | 24 | 35 | 28 | 25 | 81 | 4.85 | + 2.0 | 19 | 9,606 | sw. | 44 | s. | 5 | 3 | 5 | 20 | 8.1 | 12.0 |
| Cleveland | 762 | 190 | 201 | 29.09 | 29.93 | — .14 | 32.4 | + 5.6 | 61 | 24 | 40 | 6 | 1 | 25 | 35 | 29 | 26 | 79 | 3.22 | + 0.6 | 16 | 11,805 | s. | 58 | sw. | 6 | 2 | 9 | 17 | 7.8 | 9.8 |
| Sandusky | 629 | 62 | 70 | 29.23 | 29.93 | — .14 | 32.0 | + 4.9 | 85 | 24 | 39 | 2 | 1 | 25 | 33 | .... | .... | .... | 4.44 | + 2.0 | 12 | 6,571 | sw. | 33 | nw. | 25 | 7 | 7 | 14 | 6.8 | 9.1 |
| Toledo | 628 | 207 | 246 | 29.24 | 29.94 | — .13 | 31.4 | + 4.6 | 55 | 23 | 39 | 0 | 1 | 24 | 30 | 29 | 25 | 80 | 5.97 | + 4.0 | 13 | 11,986 | sw. | 57 | sw. | 6 | 7 | 7 | 14 | 6.8 | 13.1 |
| Detroit | 730 | 218 | 258 | 29.11 | 29.93 | — .13 | 29.2 | + 4.2 | 52 | 24 | 36 | 0 | 7 | 22 | 29 | 27 | 24 | 82 | 4.26 | + 2.1 | 12 | 11,810 | sw. | 56 | w. | 10 | 4 | 7 | 17 | 7.7 | 14.5 |

TABLE I.—*Climatological data for U. S. Weather Bureau stations, February, 1909.*—Continued.

| Stations. | Elevation of instruments. | | | Pressure, in inches. | | | Temperature of the air, in degrees Fahrenheit. | | | | | | | | | Mean wet thermometer. | Mean temperature of the dew-point. | Mean relative humidity, per cent. | Precipitation, in inches. | | | Wind. | | | | | Clear days. | Partly cloudy days. | Cloudy days. | Average cloudiness during daylight, tenths. | Total snowfall. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barometer above sea level, feet. | Thermometers above ground. | Anemometer above ground. | Actual, reduced to mean of 24 hours. | Sea level, reduced to mean of 24 hrs. | Departure from normal. | Mean max. + mean min. ÷ 2. | Departure from normal. | Maximum. | Date. | Mean maximum. | Minimum. | Date. | Mean minimum. | Greatest daily range. | | | | Total. | Departure from normal. | Days with .01, or more. | Total movement, miles. | Prevailing direction. | Maximum velocity. Miles per hour. | Maximum velocity. Direction. | Maximum velocity. Date. | | | | | |
| *Upper Lake Region.* | | | | | | | 22.5 | + 3.5 | | | | | | | | | | 83 | 2.47 | + 0.8 | | | | | | | | | | 7.6 | |
| Alpena | 609 | 13 | 92 | 29.23 | 29.92 | — .11 | 22.6 | + 4.8 | 44 | 5 | 30 | — 6 | 1 | 15 | 32 | 21 | 19 | 87 | 2.54 | + 0.8 | 17 | 8,166 | nw. | 48 | e. | 9 | 5 | 7 | 16 | 7.2 | 20.8 |
| Escanaba | 612 | 40 | 82 | 29.25 | 29.94 | — .12 | 19.6 | + 4.3 | 38 | 6 | 27 | 0 | 28 | 12 | 27 | 18 | 14 | 77 | 3.01 | + 1.7 | 11 | 6,652 | n. | 36 | e. | 9 | 3 | 7 | 18 | 7.4 | 29.5 |
| Grand Haven | 632 | 54 | 92 | 29.20 | 29.91 | — .14 | 27.1 | + 2.9 | 46 | 5 | 33 | 3 | 1 | 21 | 28 | 26 | 24 | 84 | 3.12 | + 1.2 | 13 | 9,554 | sw. | 45 | sw. | 10 | 2 | 9 | 17 | 7.7 | 12.2 |
| Grand Rapids | 707 | 121 | 162 | 29.12 | 29.92 | — .13 | 27.5 | + 2.0 | 49 | 5 | 34 | 2 | 1 | 20 | 28 | 26 | 24 | 85 | 3.06 | + 1.2 | 12 | 8,722 | s. | 38 | sw. | 10 | 3 | 6 | 19 | 8.1 | 8.4 |
| Houghton | 668 | 66 | 74 | 29.18 | 29.94 | — .11 | 16.1 | + 0.1 | 35 | 4 | 24 | —15 | 16 | 8 | 37 | .... | .... | .. | 1.92 | + 0.2 | 12 | 4,771 | nw. | 31 | n. | 24 | 1 | 11 | 16 | 7.8 | 24.1 |
| Marquette | 734 | 77 | 116 | 29.13 | 29.96 | — .09 | 18.6 | + 2.7 | 44 | 4 | 25 | 0 | 12 | 12 | 26 | 17 | 13 | 79 | 2.67 | + 1.0 | 14 | 7,295 | nw. | 47 | sw. | 1 | 1 | 10 | 17 | 7.5 | 28.0 |
| Port Huron | 638 | 70 | 120 | 29.21 | 29.92 | — .13 | 27.8 | + 5.8 | 51 | 24 | 35 | — 2 | 1 | 21 | 29 | 25 | 22 | 81 | 3.20 | + 1.0 | 13 | 9,470 | sw. | 46 | sw. | 6 | 5 | 6 | 17 | 7.6 | 20.5 |
| Sault Sainte Marie | 614 | 40 | 61 | 29.22 | 29.96 | — .08 | 15.4 | + 3.0 | 35 | 22 | 24 | —15 | 8 | 7 | 32 | 14 | 11 | 82 | 1.51 | + 0.1 | 12 | 6,529 | nw. | 36 | nw. | 24 | 1 | 5 | 22 | 8.9 | 14.7 |
| Chicago | 823 | 140 | 310 | 29.02 | 29.93 | — .15 | 32.4 | + 7.0 | 57 | 4 | 39 | 12 | 25 | 26 | 32 | 30 | 27 | 80 | 3.84 | + 1.7 | 11 | 11,644 | sw. | 48 | ne. | 14 | 4 | 3 | 21 | 7.8 | 10.1 |
| Milwaukee | 681 | 122 | 139 | 29.18 | 29.93 | — .13 | 27.4 | + 5.5 | 48 | 26 | 34 | 5 | 1 | 21 | 25 | 26 | 24 | 89 | 1.99 | + 0.1 | 11 | 8,659 | sw. | 55 | e. | 9 | 7 | 8 | 13 | 6.5 | 16.5 |
| Green Bay | 617 | 49 | 86 | 29.23 | 29.91 | — .16 | 22.2 | + 5.0 | 44 | 4 | 29 | — 1 | 11 | 15 | 24 | 20 | 17 | 80 | 1.49 | — 0.1 | 11 | 7,966 | sw. | 42 | n. | 14 | 1 | 6 | 21 | 8.2 | 13.5 |
| Duluth | 1,133 | 11 | 47 | 28.70 | 29.98 | — .10 | 12.8 | — 0.8 | 33 | 1 | 20 | —18 | 13 | 5 | 29 | 11 | 9 | 86 | 1.34 | + 0.4 | 11 | 8,891 | nw. | 60 | ne. | 9 | 4 | 16 | 8 | 5.9 | 13.1 |
| *North Dakota.* | | | | | | | 9.6 | + 2.7 | | | | | | | | | | 89 | 0.31 | — 0.2 | | | | | | | | | | 6.4 | |
| Moorhead | 940 | 8 | 57 | 28.98 | 30.05 | — .06 | 9.8 | + 2.8 | 37 | 20 | 17 | —17 | 15 | 2 | 26 | 9 | 8 | 92 | 0.34 | — 0.4 | 4 | 5,835 | n. | 30 | nw. | 9 | 9 | 4 | 15 | 6.0 | 3.6 |
| Bismarck | 1,674 | 8 | 57 | 28.20 | 30.06 | — .06 | 12.2 | + 3.9 | 54 | 3 | 22 | —22 | 10 | 3 | 40 | 11 | 8 | 86 | 0.36 | — 0.1 | 8 | 5,880 | nw. | 33 | nw. | 18 | 4 | 13 | 11 | 6.8 | 4.2 |
| Devils Lake | 1,482 | 11 | 44 | 28.36 | 30.04 | — .07 | 5.1 | + 0.6 | 34 | 19 | 14 | —25 | 14 | —4 | 33 | 4 | 3 | 91 | 0.43 | — 0.1 | 9 | 7,071 | nw. | 28 | n. | 23 | 5 | 8 | 15 | 6.5 | 6.0 |
| Williston | 1,875 | 14 | 56 | 27.92 | 30.00 | — .11 | 11.3 | + 3.4 | 44 | 3 | 20 | —29 | 13 | 2 | 13 | 10 | 8 | 88 | 0.10 | — 0.4 | 4 | 4,960 | nw. | 27 | nw. | 11 | 6 | 12 | 10 | 6.1 | 1.0 |
| *Upper Miss. Valley.* | | | | | | | 30.2 | + 5.6 | | | | | | | | | | 80 | 2.81 | + 1.1 | | | | | | | | | | 6.1 | |
| Minneapolis | ...... | 102 | 208 | ...... | ...... | ...... | 18.0 | ...... | 47 | 4 | 26 | —15 | 15 | 10 | 36 | .... | .... | ... | 2.14 | + 1.4 | 8 | 7,524 | w. | 39 | n. | 9 | 7 | 12 | 9 | 5.8 | 24.2 |
| St. Paul | 837 | 171 | 179 | 29.01 | 29.96 | — .13 | 18.2 | — 0.2 | 46 | 4 | 26 | —12 | 15 | 10 | 37 | 16 | 12 | 76 | 2.18 | + 1.3 | 9 | 7,241 | n. | 40 | nw. | 24 | 6 | 17 | 5 | 5.1 | 23.5 |
| La Crosse | 714 | 10 | 49 | 29.13 | 29.94 | — .14 | 21.6 | + 3.2 | 49 | 4 | 31 | — 8 | 16 | 13 | 33 | .... | .... | ... | 1.89 | + 0.8 | 11 | 3,655 | s. | 21 | sw. | 4 | 3 | 8 | 17 | 7.3 | 16.9 |
| Madison | 974 | 70 | 78 | 28.84 | 29.94 | — .13 | 23.6 | + 4.0 | 46 | 4 | 31 | 0 | 1 | 16 | 28 | 22 | 18 | 82 | 1.70 | + 0.2 | 8 | 8,071 | sw. | 44 | ne. | 14 | 5 | 10 | 13 | 6.7 | 12.7 |
| Charles City | 1,015 | 10 | 49 | 28.83 | 29.95 | — .15 | 21.0 | + 5.9 | 45 | 4 | 30 | — 6 | 16 | 12 | 34 | 19 | 18 | 91 | 1.54 | + 0.6 | 8 | 5,481 | s. | 30 | e. | 9 | 4 | 9 | 15 | 7.2 | 16.2 |
| Davenport | 606 | 71 | 79 | 29.25 | 29.93 | — .17 | 31.0 | + 7.2 | 59 | 4 | 40 | 6 | 10 | 22 | 39 | 28 | 26 | 84 | 2.34 | + 0.8 | 13 | 6,257 | sw. | 32 | ne. | 14 | 6 | 9 | 13 | [illegible] | 4.6 |
| Des Moines | 861 | 84 | 101 | 28.99 | 29.93 | — .18 | 29.6 | + 5.5 | 60 | 4 | 39 | 1 | 15 | 20 | 34 | 26 | 22 | 81 | 0.90 | — 0.2 | 7 | 6,755 | sw. | 43 | sw. | 9 | 10 | 16 | 12 | 5.8 | 2.9 |
| Dubuque | 698 | 100 | 117 | 29.20 | 29.96 | — .13 | 26.9 | + 5.3 | 54 | 4 | 35 | 3 | 25 | 19 | 29 | 25 | 22 | 83 | 1.32 | — 0.1 | 11 | 4,904 | s. | 28 | nw. | 24 | 5 | 10 | 13 | 6.8 | 6.9 |
| Keokuk | 614 | 64 | 77 | 29.25 | 29.95 | — .16 | 34.2 | + 7.6 | 62 | 4 | 44 | 8 | 10 | 24 | 39 | 30 | 26 | 79 | 2.44 | + 0.8 | 14 | 6,698 | sw. | 40 | sw. | 9 | 16 | 1 | 11 | 4.9 | 6.0 |
| Cairo | 356 | 87 | 93 | 29.60 | 29.99 | — .13 | 43.8 | + 6.2 | 68 | 23 | 53 | 13 | 1 | 35 | 31 | 39 | 33 | 70 | 6.76 | + 3.4 | 14 | 8,046 | s. | 38 | sw. | 9 | 6 | 11 | 11 | 6.2 | 0.5 |
| La Salle | 536 | 56 | 64 | 29.36 | 29.95 | — .13 | 31.7 | + 6.7 | 60 | 4 | 40 | 9 | 1 | 23 | 39 | .... | .... | ... | 3.06 | + 0.6 | 11 | 6,979 | sw. | 39 | sw. | 9 | 4 | 12 | 12 | 6.5 | 7.4 |
| Peoria | 609 | 11 | 45 | 29.26 | 29.94 | — .16 | 31.8 | + 5.9 | 61 | 4 | 41 | 7 | 17 | 23 | 39 | 29 | 26 | 83 | 3.67 | + 1.0 | 14 | 7,459 | s. | 42 | sw. | 9 | 8 | 9 | 11 | 6.1 | 5.0 |
| Springfield, Ill | 644 | 10 | 92 | 29.24 | 29.94 | — .16 | 34.7 | + 5.6 | 62 | 4 | 43 | 9 | 1 | 26 | 38 | 31 | 28 | 82 | 4.34 | + 1.6 | 11 | 7,019 | s. | 33 | sw. | 9 | 10 | 7 | 11 | 5.8 | 7.6 |
| Hannibal | 534 | 75 | 109 | 29.36 | 29.95 | — .16 | 34.8 | + 5.7 | 64 | 4 | 45 | 9 | 9 | 25 | 42 | ... | .... | ... | 3.95 | + 2.4 | 13 | 8,029 | sw. | 48 | sw. | 9 | 14 | 2 | 12 | 5.5 | 5.8 |
| St. Louis | 567 | 208 | 217 | 29.32 | 29.94 | — .17 | 39.4 | + 5.9 | 65 | 4 | 48 | 13 | 1 | 31 | 37 | 35 | 30 | 72 | 3.94 | + 1.2 | 11 | 8,955 | s. | 40 | nw. | 24 | 9 | 7 | 12 | 5.8 | 4.7 |
| *Missouri Valley.* | | | | | | | 29.8 | + 5.4 | | | | | | | | | | 75 | 1.51 | + 0.5 | | | | | | | | | | 5.2 | |
| Columbia, Mo | 784 | 11 | 84 | 29.10 | 29.95 | — .16 | 37.1 | + 7.0 | 65 | 28 | 48 | 9 | 10 | 26 | 38 | .. | .... | ... | 2.87 | + 0.7 | 11 | 7,514 | sw. | 46 | sw. | 9 | 13 | 5 | 10 | 4.6 | 6.5 |
| Kansas City | 963 | 116 | 181 | 28.88 | 29.94 | — .17 | 37.0 | + 7.1 | 67 | 28 | 48 | 4 | 9 | 26 | 51 | 31 | 26 | 71 | 1.75 | + 0.2 | 10 | 10,030 | s. | 52 | ne. | 14 | 14 | 3 | 11 | 4.6 | 3.4 |
| Springfield, Mo | 1,324 | 98 | 104 | 28.53 | 29.96 | — .15 | 40.0 | + 6.4 | 67 | 12 | 51 | 5 | 16 | 29 | 38 | 35 | 29 | 71 | 1.61 | — 0.7 | 10 | 9,091 | s. | 49 | w. | 14 | 15 | 3 | 10 | 4.4 | 5.0 |
| Iola | 984 | 11 | 50 | 28.90 | 29.98 | — .12 | 38.4 | + 6.4 | 68 | 28 | 51 | 4 | 16 | 26 | 53 | .... | .... | ... | 1.63 | + 0.5 | 10 | 7,016 | s. | 35 | nw. | 9 | 10 | 8 | 10 | 5.4 | 1.9 |
| Topeka | ..... | 85 | 89 | ..... | ..... | ..... | 35.6 | + 5.6 | 68 | 28 | 48 | 2 | 9 | 24 | 41 | .... | .... | ... | 1.06 | — 0.3 | 7 | 8,725 | s. | 47 | w. | 9 | 15 | 4 | 9 | 4.2 | 1.6 |
| Lincoln | 1,189 | 11 | 84 | 28.64 | 29.95 | — .15 | 31.2 | + 6.4 | 67 | 3 | 43 | — 6 | 15 | 20 | 37 | 26 | 21 | 73 | 1.13 | + 0.4 | 6 | 8,371 | s. | 58 | nw. | 9 | 10 | 10 | 8 | 5.2 | 2.7 |
| Omaha | 1,105 | 115 | 121 | 28.73 | 29.95 | — .16 | 30.4 | + 6.7 | 61 | 3 | 40 | — 6 | 15 | 21 | 41 | 26 | 21 | 73 | 1.21 | + 0.4 | 5 | 6,964 | nw. | 39 | nw. | 23 | 8 | 8 | 12 | 5.9 | 4.7 |
| Valentine | 2,598 | 47 | 54 | 27.18 | 30.00 | — .09 | 23.8 | + 2.6 | 66 | 3 | 36 | —17 | 9 | 11 | 45 | 20 | 15 | 75 | 0.86 | + 0.3 | 6 | 6,654 | w. | 30 | nw. | 23 | 9 | 17 | 2 | 4.5 | 9.4 |
| Sioux City | 1,135 | 96 | 164 | 28.71 | 29.97 | — .15 | 23.6 | + 3.8 | 54 | 3 | 32 | —17 | 15 | 15 | 34 | 21 | 17 | 78 | 2.24 | + 1.7 | 6 | 3,142 | nw. | 53 | nw. | 9 | 6 | 7 | 15 | 6.5 | 20.3 |
| Pierre | 1,572 | 70 | 75 | 28.29 | 30.03 | — .08 | 22.0 | + 5.1 | 57 | 3 | 31 | —13 | 15 | 13 | 39 | 17 | 12 | 69 | 0.42 | 0.0 | 2 | 6,165 | e. | 42 | nw. | 9 | 8 | 14 | 6 | 5.0 | 6.7 |
| Huron | 1,306 | 56 | 67 | 28.57 | 30.03 | — .09 | 15.9 | + 3.0 | 49 | 3 | 26 | —21 | 15 | 6 | 32 | 15 | 13 | 89 | 1.55 | + 1.1 | 7 | 7,545 | nw. | 48 | nw. | 9 | 10 | 6 | 12 | 5.4 | 15.8 |
| Yankton | 1,233 | 49 | 57 | 28.60 | 29.97 | — .15 | 22.4 | + 4.2 | 59 | 3 | 32 | —18 | 15 | 12 | 39 | .... | .... | ... | 1.75 | + 1.2 | 5 | 6,160 | nw. | 47 | nw. | 9 | 4 | 12 | 12 | 6.4 | 18.8 |
| *Northern Slope.* | | | | | | | 24.3 | + 2.8 | | | | | | | | | | 72 | 0.82 | 0.0 | | | | | | | | | | 5.7 | |
| Havre | 2,505 | 11 | 44 | 27.25 | 29.97 | — .10 | 17.0 | + 2.0 | 59 | 3 | 26 | —27 | 14 | 8 | 37 | 15 | 12 | 83 | 0.43 | 0.0 | 6 | 5,575 | e. | 36 | w. | 17 | 8 | 16 | 4 | 5.1 | 1.6 |
| Miles City | 2,371 | 26 | 48 | 27.39 | 30.04 | — .05 | 23.9 | + 7.2 | 52 | 28 | 34 | —22 | 14 | 14 | 40 | 20 | 16 | 77 | 0.68 | + 0.1 | 5 | 3,951 | se. | 26 | w. | 25 | 10 | 15 | 3 | 4.6 | 3.6 |
| Helena | 4,110 | 8 | 56 | 25.66 | 29.98 | — .13 | 24.4 | + 2.2 | 50 | 3 | 33 | —11 | 8 | 16 | 39 | 21 | 15 | 68 | 0.41 | — 0.3 | 7 | 4,496 | w. | 37 | w. | 5 | 2 | 11 | 15 | 7.2 | 2.9 |
| Kalispell | 2,962 | 11 | 34 | 26.78 | 29.91 | — .17 | 26.8 | + 3.0 | 45 | 17 | 34 | — 2 | 8 | 20 | 28 | 24 | 20 | 79 | 1.11 | — 0.4 | 14 | 2,779 | sw. | 23 | sw. | 3 | 3 | 9 | 16 | 7.4 | 8.6 |
| Rapid City | 3,234 | 46 | 50 | 26.48 | 30.02 | — .06 | 26.4 | + 2.9 | 69 | 3 | 37 | —12 | 8 | 16 | 51 | 21 | 14 | 65 | 0.31 | — 0.2 | 4 | 4,686 | w. | 29 | n. | 8 | 8 | 10 | 10 | 5.4 | 4.6 |
| Cheyenne | 6,088 | 56 | 64 | 23.84 | 29.96 | — .07 | 27.6 | + 1.3 | 61 | 3 | 39 | —11 | 8 | 16 | 14 | 22 | 14 | 57 | 1.42 | + 0.9 | 7 | 9,742 | nw. | 46 | nw. | 9 | 15 | 9 | 4 | 4.1 | 15.9 |
| Lander | 5,372 | 26 | 36 | 24.50 | 30.00 | — .08 | 24.5 | + 2.7 | 54 | 3 | 39 | —24 | 9 | 10 | 50 | 20 | 15 | 70 | 0.76 | + 0.1 | 4 | 2,437 | nw. | 27 | ne. | 17 | 7 | 16 | 5 | 5.2 | 7.6 |
| Sheridan | 3,790 | 9 | 47 | 25.96 | 29.98 | ...... | 24.2 | ...... | 55 | 3 | 35 | —14 | 9 | 13 | 41 | 20 | 14 | 68 | 0.32 | ...... | 5 | 4,127 | nw. | 44 | w. | 24 | 5 | 15 | 8 | 5.9 | 4.3 |
| Yellowstone Park | 6,200 | 11 | 48 | 23.72 | 30.02 | — .08 | 21.0 | + 1.4 | 43 | 3 | 30 | —10 | 8 | 12 | 31 | 18 | 14 | 75 | 0.65 | — 1.2 | 10 | 6,443 | s. | 30 | sw. | 3 | 1 | 7 | 20 | 8.2 | 12.2 |
| North Platte | 2,821 | 11 | 51 | 26.98 | 30.02 | — .05 | 27.0 | + 2.4 | 72 | 8 | 42 | —15 | 15 | 12 | 51 | 21 | 16 | 75 | 1.61 | + 1.2 | 7 | 6,257 | w. | 40 | nw. | 8 | 15 | 7 | 6 | 3.9 | 14.2 |
| *Middle Slope.* | | | | | | | 36.6 | + 4.2 | | | | | | | | | | 57 | 0.68 | — 0.1 | | | | | | | | | | 4.1 | |
| Denver | 5,291 | 129 | 136 | 24.58 | 29.95 | — .06 | 33.2 | + 2.1 | 64 | 2 | 46 | — 1 | 14 | 21 | 44 | 26 | 18 | 57 | 1.35 | + 0.9 | 5 | 5,742 | sw. | 38 | w. | 20 | 15 | 8 | 5 | 4.0 | 18.3 |
| Leadville | 10,248 | 7 | .... | ...... | ...... | ...... | ...... | ...... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | ...... | ...... | .... | ...... | .... | .... | .... | .... | .... | .... | .... | .... | |
| Pueblo | 4,685 | 80 | 86 | 25.16 | 29.92 | — .08 | 34.8 | + 3.0 | 70 | 3 | 50 | — 8 | 15 | 19 | 51 | 27 | 14 | 47 | 0.63 | + 0.2 | 4 | 6,022 | nw. | 49 | w. | 8 | 18 | 7 | 3 | 2.9 | 12.3 |
| Concordia | 1,398 | 42 | 50 | 28.45 | 29.96 | — .13 | 33.8 | + 5.0 | 69 | 3 | 48 | — 2 | 9 | 20 | 63 | 28 | 22 | 69 | 0.49 | — 0.3 | 3 | 5,537 | nw. | 36 | nw. | 8 | 12 | 10 | 6 | 4.6 | 0.8 |
| Dodge City | 2,509 | 44 | 54 | 27.29 | 29.96 | — .10 | 36.2 | + 5.1 | 71 | 28 | 53 | — 3 | 14 | 20 | 67 | 27 | 17 | 54 | 0.16 | — 0.6 | 3 | 7,184 | nw. | 39 | s. | 8 | 18 | 7 | 3 | 3.1 | 1.2 |
| Wichita | 1,358 | 90 | 120 | 28.52 | 29.98 | — .10 | 38.0 | + 5.0 | 71 | 28 | 51 | 1 | 9 | 25 | 37 | 31 | 22 | 58 | 0.89 | — 0.2 | 7 | 9,536 | s. | 42 | nw. | 8 | 9 | 14 | 5 | 5.0 | 3.4 |
| Oklahoma | 1,214 | 10 | 47 | 28.65 | 29.96 | — .11 | 43.6 | + 5.1 | 77 | 12 | 57 | 7 | 15 | 30 | 48 | 35 | 26 | 57 | 0.57 | — 0.4 | 5 | 12,990 | s. | 54 | n. | 5 | 9 | 11 | 8 | 4.9 | 0.8 |
| *Southern Slope.* | | | | | | | 49.4 | + 4.9 | | | | | | | | | | 45 | 0.16 | — 1.0 | | | | | | | | | | 4.0 | |
| Abilene | 1,738 | 45 | 54 | 28.17 | 30.00 | — .05 | 52.7 | + 7.9 | 80 | 12 | 66 | 13 | 14 | 40 | 45 | 40 | 24 | 39 | 0.00 | — 1.1 | 0 | 7,656 | s. | 37 | nw. | 18 | 9 | 15 | 4 | 4.8 | .... |
| Amarillo | 3,676 | 10 | 49 | 26.17 | 29.94 | — .08 | 41.7 | + 4.5 | 72 | 12 | 56 | 3 | 14 | 27 | 55 | 32 | 22 | 52 | 0.28 | — 0.6 | 3 | 10,264 | s. | 48 | w. | 8 | 22 | 6 | 0 | 2.9 | T |
| Del Rio | 944 | 8 | 57 | 29.03 | 30.02 | + .02 | 58.2 | + 4.6 | 91 | 20 | 73 | 23 | 15 | 44 | 55 | ... | .... | ... | 0.32 | — 1.5 | 3 | 6,586 | e. | 42 | nw. | 14 | 17 | 7 | 4 | 3.7 | ... |
| Roswell | 3,578 | 9 | 57 | 26.51 | 29.98 | .09 | 44.9 | + 2.4 | 75 | 12 | 63 | 8 | 15 | 27 | 58 | 34 | 21 | 45 | 0.02 | — 0.6 | 1 | 6,152 | sw. | 48 | nw. | 5 | 12 | 9 | 7 | 4.5 | 0.2 |
| *Southern Plateau.* | | | | | | | 45.0 | — 1.8 | | | | | | | | | | 54 | 1.18 | 0.0 | | | | | | | | | | 3.8 | |
| El Paso | 3,762 | 110 | 133 | 26.18 | 29.98 | + .03 | 47.8 | — 1.1 | 70 | 17 | 61 | 22 | 15 | 34 | 41 | 36 | 19 | 37 | 0.16 | — 0.3 | 2 | 8,881 | w. | 58 | w. | 4 | 15 | 11 | 2 | 3.1 | 0.6 |
| Santa Fe | 7,013 | 33 | 39 | 23.15 | 30.00 | + .02 | 31.0 | — 1.0 | 50 | 12 | 42 | 3 | 23 | 20 | 31 | 26 | 19 | 64 | 0.56 | — 0.3 | 7 | 6,634 | ne. | 47 | w. | 8 | 14 | 8 | 6 | 3.8 | 6.3 |
| Flagstaff | 6,907 | 8 | 57 | 23.28 | 29.99 | — .01 | 27.4 | — 3.4 | 51 | 16 | 41 | — 4 | 24 | 14 | 52 | 24 | 19 | 72 | 2.88 | — 0.4 | 9 | 5,304 | sw. | 48 | sw. | 8 | 9 | 9 | 10 | 5.6 | 20.9 |
| Phoenix | 1,108 | 50 | 56 | 28.84 | 30.02 | + .03 | 53.5 | — 0.9 | 77 | 2 | 67 | 32 | 10 | 40 | 34 | 44 | 32 | 49 | 0.68 | 0.6 | 5 | 2,921 | e. | 28 | sw. | 21 | 15 | 9 | 4 | 3.7 | .... |
| Yuma | 141 | 9 | 58 | 29.89 | 30.04 | + .04 | 57.8 | — 1.4 | 83 | 18 | 72 | 36 | 9 | 44 | 40 | 46 | 31 | 42 | 0.08 | — 0.5 | 2 | 4,776 | w. | 36 | w. | 21 | 22 | 4 | 2 | 1.8 | .... |
| Brawley | †105 | 11 | 31 | 30.15 | 30.03 | ...... | 57.0 | ...... | 84 | 19 | 71 | 32 | 24 | 43 | 40 | 48 | 38 | 53 | 0.23 | ...... | 3 | 4,686 | nw. | 35 | w. | 21 | 14 | 11 | 3 | 3.7 | .... |
| Independence | 3,910 | 11 | 42 | 25.97 | 30.00 | — .06 | 40.3 | — 3.4 | 63 | 17 | 52 | 19 | 9 | 29 | 33 | 35 | 27 | 63 | 2.73 | + 1.5 | 6 | 4,735 | nw. | 42 | w. | 19 | 12 | 10 | 6 | 4.8 | 16.7 |
| *Middle Plateau.* | | | | | | | 33.4 | + 1.5 | | | | | | | | | | 66 | 1.29 | + 0.2 | | | | | | | | | | 5.6 | |
| Reno | 4,532 | 56 | 63 | 25.40 | 30.00 | — .08 | 37.3 | + 1.7 | 61 | 2 | 48 | 9 | 9 | 27 | 34 | 32 | 25 | 63 | 0.91 | — 0.9 | 5 | 4,196 | w. | 28 | s. | 3 | 8 | 13 | 7 | 5.2 | 7.2 |
| Tonopah | 6,089 | 12 | 20 | 24.00 | 30.10 | ...... | 32.1 | + 3.8 | 50 | 28 | 39 | 14 | 22 | 25 | 25 | 28 | 21 | 63 | 0.49 | — 0.3 | 5 | 7,912 | se. | 43 | nw. | 21 | 7 | 13 | 8 | 5.6 | 7.2 |
| Winnemucca | 4,344 | 18 | 56 | 25.55 | 30.00 | — .09 | 35.1 | + 1.8 | 58 | 2 | 45 | 3 | 22 | 25 | 33 | 31 | 27 | 75 | 1.39 | + 0.5 | 12 | 4,734 | sw. | 34 | sw. | 6 | 6 | 7 | 15 | 6.5 | 9.6 |
| Modena | 5,479 | 10 | 43 | 24.57 | 30.01 | — .03 | 31.4 | — 0.2 | 54 | 2 | 42 | 7 | 9 | 21 | 32 | 28 | 24 | 72 | 1.04 | + 0.3 | 9 | 6,993 | w. | 48 | w. | 8 | 6 | 14 | 8 | 5.8 | 8.0 |
| Salt Lake City | 4,366 | 105 | 110 | 25.57 | 30.00 | — .08 | 35.9 | + 3.0 | 56 | 28 | 43 | 17 | 6 | 29 | 26 | 31 | 24 | 62 | 1.89 | + 0.5 | 6 | 4,762 | se. | 38 | nw. | 17 | 6 | 9 | 13 | 6.4 | 12.7 |
| Durango | 6,546 | 18 | 56 | 23.56 | 30.03 | + .03 | 27.2 | — 2.7 | 51 | 2 | 40 | 0 | 24 | 14 | 38 | 22 | 17 | 68 | 2.97 | + 1.6 | 10 | 3,543 | nw. | 26 | w. | 8 | 10 | 11 | 7 | 4.6 | 27.2 |
| Grand Junction | 4,608 | 43 | 51 | 25.34 | 29.98 | — 0.6 | 34.6 | + 3.1 | 52 | 12 | 43 | 16 | 6 | 26 | 26 | 28 | 21 | 62 | 0.34 | — 0.2 | 6 | 3,536 | nw. | 34 | sw. | 8 | 9 | 11 | 8 | 5.3 | 1.4 |
| *Northern Plateau.* | | | | | | | 37.7 | + 5.6 | | | | | | | | | | 71 | 1.90 | + 0.5 | | | | | | | | | | 7.8 | |
| Baker City | 3,471 | 48 | 58 | 26.33 | 29.96 | — .16 | 34.4 | + 6.5 | 50 | 2 | 41 | 19 | 7 | 28 | 19 | 31 | 28 | 76 | 1.35 | 0.0 | 15 | 4,386 | s. | 23 | nw. | 21 | 1 | 13 | 14 | 7.1 | 10.5 |
| Boise | 2,739 | [illegible] | 86 | 27.11 | 30.00 | — .12 | 39.6 | + 5.8 | 58 | 3 | 46 | 23 | 22 | 34 | 22 | 34 | 26 | 60 | 1.92 | + 0.5 | 15 | 5,322 | se. | 30 | se. | 3 | 2 | 2 | 24 | 8.4 | 5.1 |
| Lewiston | 757 | 10 | 51 | 29.11 | 29.93 | — .18 | 41.4 | + 5.2 | 54 | 26 | 48 | 29 | 22 | 35 | 18 | .... | .... | .... | 0.85 | — 0.5 | 13 | 3,565 | e. | 40 | nw. | 3 | 0 | 9 | 19 | 8.2 | 0.2 |
| Pocatello | 4,477 | 46 | 84 | 25.40 | 30.01 | — .09 | 32.2 | + 4.1 | 51 | 3 | 38 | 13 | 22 | 26 | 21 | 29 | 25 | 75 | 2.86 | + 2.0 | 11 | 8,541 | se. | 36 | sw. | 8 | 0 | 15 | 13 | 7.5 | 23.0 |
| Spokane | 1,929 | 101 | 110 | 27.83 | 29.92 | — .17 | 35.2 | + 5.1 | 54 | 3 | 42 | 12 | 12 | 29 | 21 | 33 | 29 | 78 | 1.96 | 0.0 | 14 | 4,647 | sw. | 29 | sw. | 5 | 1 | 9 | 18 | 8.2 | 9.1 |
| Walla Walla | 1,000 | 71 | 79 | 28.85 | 29.93 | — .18 | 43.2 | + 6.8 | 65 | 2 | 50 | 24 | 13 | 37 | 30 | 38 | 31 | 66 | 2.43 | + 0.8 | 11 | 6,067 | s. | 39 | se. | 2 | 3 | 10 | 15 | 7.7 | 2.5 |
| *N. Pac. Coast Reg.* | | | | | | | 42.0 | + 1.3 | | | | | | | | | | 85 | 7.45 | + 2.0 | | | | | | | | | | 8.2 | |
| Blaine | 57 | 4 | .... | ...... | ...... | ...... | ...... | ...... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | ...... | ...... | .... | ...... | .... | .... | .... | .... | .... | .... | .... | .... | |
| North Head | 211 | 11 | 56 | 29.62 | 29.85 | — .21 | 42.6 | + 0.5 | 51 | 1 | 46 | 33 | 8 | 39 | 11 | 41 | 40 | 89 | 10.14 | + 4.4 | 27 | 15,099 | se. | 76 | se. | 14 | 1 | 2 | 25 | 9.2 | T. |
| Port Crescent | 259 | 12 | 29 | 29.56 | 29.85 | — .18 | 38.4 | + 1.2 | 55 | 16 | 44 | 27 | 11 | 33 | 14 | .... | .... | .... | 5.03 | + 0.3 | 20 | 3,191 | ne. | 20 | sw. | 16 | 2 | 16 | 10 | 7.0 | T. |

TABLE I.—*Climatological data for U. S. Weather Bureau stations, February, 1909*—Continued.

| Stations. | Elevation of instruments: Barometer above sea level, feet. | Elevation of instruments: Thermometers above ground. | Elevation of instruments: Anemometer above ground. | Pressure, in inches: Actual, reduced to mean of 24 hours. | Pressure, in inches: Sea level, reduced to mean of 24 hrs. | Pressure, in inches: Departure from normal. | Temperature: Mean max. + mean min. ÷ 2. | Temperature: Departure from normal. | Temperature: Maximum. | Temperature: Date. | Temperature: Mean maximum. | Temperature: Minimum. | Temperature: Date. | Temperature: Mean minimum. | Temperature: Greatest daily range. | Mean wet thermometer. | Mean temperature of the dew-point. | Mean relative humidity, per cent. | Precipitation, in inches: Total. | Precipitation: Departure from normal. | Precipitation: Days with .01, or more. | Wind: Total movement, miles. | Wind: Prevailing direction. | Wind: Maximum velocity, Miles per hour. | Wind: Maximum velocity, Direction. | Wind: Maximum velocity, Date. | Clear days. | Partly cloudy days. | Cloudy days. | Average cloudiness during daylight, tenths. | Total snowfall. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *N. P. Coast Reg*—Cont. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Seattle | 123 | 185 | 224 | 29.76 | 29.89 | − .17 | 42.0 | + 1.5 | 54 | 16 | 46 | 28 | 13 | 38 | 17 | 40 | 38 | 88 | 4.35 | + 0.5 | 20 | 7,398 | s. | 49 | s. | 19 | 0 | 3 | 25 | 9.0 | 1.0 |
| Tacoma | 213 | 118 | 120 | 29.64 | 29.87 | − .19 | 41.6 | + 1.2 | 54 | 16 | 47 | 29 | 13 | 37 | 20 | 40 | 38 | 85 | 5.33 | + 0.2 | 23 | 5,149 | sw. | 37 | sw. | 4 | 2 | 9 | 17 | 7.6 | 4.7 |
| Tatoosh Island | 86 | 7 | 57 | 29.69 | 29.79 | − .21 | 41.6 | + 0.6 | 51 | 2 | 45 | 33 | 12 | 38 | 12 | 40 | 37 | 85 | 13.08 | + 4.3 | 24 | 12,703 | se. | 62 | e. | 12 | 1 | 5 | 22 | 8.2 | T. |
| Portland, Oreg. | 153 | 68 | 106 | 29.75 | 29.91 | − .17 | 43.3 | + 2.0 | 60 | 16 | 48 | 33 | 21 | 38 | 16 | 41 | 38 | 82 | 7.03 | + 1.3 | 23 | 5,451 | sw. | 32 | s. | 18 | 0 | 8 | 20 | 8.2 | |
| Roseburg | 510 | 9 | 57 | 29.40 | 29.95 | − .15 | 44.7 | + 2.1 | 64 | 1 | 51 | 31 | 10 | 38 | 20 | 42 | 38 | 80 | 7.22 | + 2.7 | 22 | 2,498 | s. | 28 | sw. | 18 | 0 | 10 | 18 | 7.9 | 0.5 |
| *Mid. Pac. Coast Reg.* | | | | | | | 49.4 | − 0.2 | | | | | | | | | | 84 | 7.53 | + 3.6 | | | | | | | | | | 6.6 | |
| Eureka | 62 | 62 | 80 | 29.96 | 30.03 | − .08 | 47.8 | + 1.0 | 62 | 1 | 53 | 34 | 5 | 43 | 19 | 45 | 43 | 84 | 11.54 | + 4.5 | 24 | 6,004 | se. | 43 | n. | 20 | 1 | 8 | 19 | 7.7 | |
| Mount Tamalpais | 2,375 | 11 | 18 | 27.56 | 30.07 | − .03 | 42.4 | | 55 | 28 | 47 | 32 | 7 | 38 | 16 | 41 | 41 | 97 | 8.10 | + 4.3 | 21 | 13,264 | nw. | 64 | nw. | 21 | 4 | 8 | 16 | 7.0 | 0.1 |
| Point Reyes Light | 490 | 7 | 18 | 29.51 | 30.02 | | 49.2 | | 57 | 28 | 53 | 40 | 7 | 46 | 12 | | | | 5.71 | | 21 | 15,862 | nw. | 82 | nw. | 21 | 5 | 9 | 14 | 3.9 | |
| Red Bluff | 332 | 50 | 56 | 29.69 | 30.05 | − .06 | 47.9 | − 1.3 | 64 | 28 | 54 | 34 | 25 | 42 | 23 | 45 | 42 | 82 | 8.20 | + 4.6 | 15 | 4,781 | se. | 34 | s. | 3 | 6 | 9 | 13 | 6.5 | |
| Sacramento | 69 | 106 | 117 | 30.00 | 30.08 | − .01 | 49.4 | − 0.8 | 65 | 28 | 55 | 37 | 9 | 44 | 19 | 46 | 43 | 79 | 6.68 | + 3.5 | 17 | 6,836 | se. | 44 | s. | 20 | 6 | 7 | 15 | 6.4 | |
| San Francisco | 155 | 200 | 204 | 29.91 | 30.08 | − .02 | 51.3 | 0.0 | 62 | 17 | 56 | 42 | 7 | 46 | 16 | 48 | 45 | 80 | 7.53 | + 3.8 | 18 | 5,209 | w. | 34 | sw. | 11 | 4 | 11 | 13 | 6.6 | |
| San Jose | 141 | 78 | 88 | 29.+3 | 30.08 | | 50.7 | + 0.1 | 69 | 16 | 59 | 36 | 9 | 42 | 29 | | | | 4.87 | + 2.3 | 19 | 5,349 | se. | 36 | se. | 2 | 9 | 12 | 7 | 5.2 | |
| Southeast Farallon | 30 | 9 | 17 | 30.04 | 30.07 | | 51.0 | | 57 | 18 | 54 | 44 | 7 | 48 | 9 | | | | 5.78 | + 2.0 | 20 | 11,807 | nw. | 64 | nw. | 21 | 4 | 14 | 10 | 6.5 | |
| *S. Pac. Coast Reg.* | | | | | | | 52.4 | − 0.2 | | | | | | | | | | 76 | 4.04 | + 1.5 | | | | | | | | | | 5.9 | |
| Fresno | 330 | 67 | 70 | 29.75 | 30.12 | + .04 | 49.6 | + 0.4 | 70 | 28 | 58 | 33 | 22 | 41 | 32 | 46 | 42 | 78 | 2.76 | + 1.4 | 11 | 3,560 | nw. | 27 | nw. | 21 | 8 | 5 | 15 | 6.7 | |
| Los Angeles | 338 | 159 | 191 | 29.72 | 30.09 | + .03 | 54.0 | − 0.1 | 73 | 16 | 61 | 42 | 8 | 47 | 23 | 48 | 43 | 72 | 5.20 | + 2.3 | 10 | 4,788 | ne. | 32 | s. | 12 | 7 | 13 | 8 | 5.9 | |
| San Diego | 87 | 94 | 102 | 30.00 | 30.10 | + .04 | 54.2 | − 0.4 | 74 | 2 | 61 | 41 | 23 | 47 | 26 | 50 | 46 | 77 | 1.76 | − 0.2 | 8 | 4,522 | nw. | 34 | nw. | 21 | 14 | 7 | 7 | 4.7 | |
| San Luis Obispo | 201 | 47 | 54 | 29.90 | 30.13 | + .02 | 52.0 | − 0.5 | 72 | 17 | 60 | 37 | 8 | 44 | 31 | 48 | 44 | 77 | 6.44 | + 2.9 | 12 | 4,058 | nw. | 24 | s. | 11 | 6 | 9 | 13 | 6.3 | |
| *West Indies.* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Grand Turk | 11 | 6 | 20 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| San Juan | 82 | 48 | 90 | 29.96 | 30.05 | + .00 | 74.6 | | 84 | 28 | 80 | 64 | 26 | 69 | 15 | 70 | 68 | 83 | 2.16 | − 0.2 | 19 | 8,683 | e. | 34 | se. | 23 | 14 | 11 | 3 | 3.8 | |
| *Panama.* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Christobal | 17 | 5 | 60 | 29.87 | 29.89 | | 78.9 | | 84 | 12 | 82 | 72 | 16 | 76 | 10 | 74 | 73 | 82 | 1.92 | | 17 | 9,459 | n. | 32 | n. | 1 | 9 | 16 | 3 | 5.0 | |
| Bas Obispo | 172 | 4 | 30 | 29.71 | 29.88 | | 77.5 | | 89 | 22 | 86 | 66 | 26 | 69 | 21 | 72 | 71 | 92 | 4.72 | | 10 | 3,292 | nw. | 18 | ne. | 1 | 4 | 20 | 4 | 5.0 | |
| Ancon | 92 | 6 | 69 | 29.77 | 29.87 | | 80.3 | | 92 | 11 | 89 | 70 | 28 | 72 | 21 | 72 | 71 | 84 | 2.90 | | 8 | 6,070 | nw. | 23 | nw. | 14 | 8 | 16 | 4 | 5.0 | |
| Alhajuela | | | | | | | | | | | | | | | | | | | 3.71 | | 10 | | | | | | | | | | |
| Bohio | | | | | | | | | | | | | | | | | | | 3.74 | | 18 | | | | | | | | | | |
| Gatun | | | | | | | | | | | | | | | | | | | 4.12 | | 20 | | | | | | | | | | |

† Below sea level.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for storms in which the rate of fall equaled or exceeded 0.25 in any 5 minutes, or 0.80 inch in 1 hour, during February, 1909, at all stations furnished with self-registering gages.*

| Stations. | Date. | Total duration: From— | Total duration: To— | Total amount of precipitation. | Excessive rate: Began— | Excessive rate: Ended— | Amount before excessive began. | 5 min. | 10 min. | 15 min. | 20 min. | 25 min. | 30 min. | 35 min. | 40 min. | 45 min. | 50 min. | 60 min. | 80 min. | 100 min. | 120 min. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Abilene, Tex. † | † | | | | | | | | | | | | | | | | | | | | |
| Albany, N. Y | 19–20 | | | 1.63 | | | | | | | | | | | | | | * | | | |
| Alpena, Mich. | 5–6 | | | 0.82 | | | | | | | | | | | | | | * | | | |
| Amarillo, Tex. | 18 | | | 0.24 | | | | | | | | | | | | | | 0.11 | | | |
| Anniston, Ala. | 5 | 1:25 p. m. | 5:45 p. m. | 0.96 | 3:56 p. m. | 4:18 p. m. | 0.12 | 0.18 | 0.31 | 0.45 | 0.51 | 0.55 | | | | | | | | | |
| Do | 9 | 11:30 a. m. | 8:15 p. m. | 1.80 | 12:07 p. m. | 12:57 p. m. | 0.10 | 0.08 | 0.12 | 0.14 | 0.21 | 0.29 | 0.43 | 0.58 | 0.65 | 0.72 | 0.77 | | | | |
| Do | 13 | 6:40 a. m. | 10:00 a. m. | 0.74 | 7:03 a. m. | 7:35 a. m. | 0.03 | 0.08 | 0.18 | 0.30 | 0.38 | 0.46 | 0.55 | | | | | | | | |
| Asheville, N. C. | 19 | | | 0.67 | | | | | | | | | | | | | | 0.43 | | | |
| Atlanta, Ga. | 5 | 4:50 p. m. | 9:05 p. m. | 0.74 | 6:00 p. m. | 6:20 p. m. | 0.05 | 0.34 | 0.42 | 0.49 | 0.56 | | | | | | | | | | |
| Do | 22 | 4:50 p. m. | 11:10 p. m. | 1.06 | 8:09 p. m. | 8:29 p. m. | 0.46 | 0.08 | 0.34 | 0.48 | 0.53 | | | | | | | | | | |
| Atlantic City, N. J | 23 | | | 1.02 | | | | | | | | | | | | | | 0.36 | | | |
| Augusta, Ga. | 22–23 | 7:50 p. m | D. N. | 2.08 | 11:09 p. m. | 11:58 p. m. | 0.81 | 0.20 | 0.28 | 0.31 | 0.35 | 0.42 | 0.56 | 0.80 | 0.97 | 1.06 | 1.15 | | | | |
| Baker City, Oreg. | 16 | | | 0.43 | | | | | | | | | | | | | | 0.25 | | | |
| Baltimore, Md | 19 | | | 0.48 | | | | | | | | | | | | | | 0.29 | | | |
| Bentonville, Ark. | 13 | 6:05 p. m. | 8:20 p. m. | 0.74 | 6:54 p. m. | 7:06 p. m. | 0.01 | 0.19 | 0.54 | 0.58 | | | | | | | | | | | |
| Binghamton, N. Y | 23 | | | 0.39 | | | | | | | | | | | | | | 0.16 | | | |
| Birmingham, Ala. | 5 | 1:03 p. m. | 4:30 p. m. | 0.71 | 2:33 p. m. | 2:43 p. m. | 0.02 | 0.23 | 0.43 | | | | | | | | | | | | |
| Do | 22 | D. N. | 4:15 a. m. | 1.15 | 1:55 a. m. | 2:20 a. m. | 0.21 | 0.18 | 0.39 | 0.52 | 0.64 | 0.76 | | | | | | | | | |
| Bismarck, N. Dak | 8–9 | | | 0.24 | | | | | | | | | | | | | | * | | | |
| Block Island, R. I. | 16 | | | 2.64 | | | | | | | | | | | | | | * | | | |
| Boise, Idaho | 18 | | | 0.43 | | | | | | | | | | | | | | 0.17 | | | |
| Boston, Mass. | 20 | | | 0.72 | | | | | | | | | | | | | | 0.27 | | | |
| Buffalo, N. Y | 23 | | | 0.39 | | | | | | | | | | | | | | 0.08 | | | |
| Burlington, Vt. | 19–20 | | | 1.17 | | | | | | | | | | | | | | * | | | |
| Cairo, Ill. | 22–23 | 7:59 p. m. | 9:40 a. m. | 2.94 | 12:48 a. m. | 1:18 a. m. | 0.05 | 0.09 | 0.28 | 0.41 | 0.44 | 0.50 | 0.57 | | | | | | | | |
| Canton, N. Y | 10 | | | 0.92 | | | | | | | | | | | | | | 0.32 | | | |
| Charles City, Iowa. | 8–9 | | | 0.76 | | | | | | | | | | | | | | * | | | |
| Charleston, S. C | 13 | | | 0.47 | | | | | | | | | | | | | | 0.27 | | | |
| Charlotte, N. C. | 22 | | | 0.44 | | | | | | | | | | | | | | 0.29 | | | |
| Chattanooga, Tenn | 13 | | | 0.61 | | | | | | | | | | | | | | 0.40 | | | |
| Cheyenne, Wyo. | 21–22 | | | 1.02 | | | | | | | | | | | | | | * | | | |
| Chicago, Ill | 8–9 | | | 0.96 | | | | | | | | | | | | | | * | | | |
| Cincinnati, Ohio. | 23 | | | 2.69 | | | | | | | | | | | | | | 0.38 | | | |
| Cleveland, Ohio. | 23 | | | 0.46 | | | | | | | | | | | | | | 0.14 | | | |
| Columbia, Mo. | 14 | | | 0.49 | | | | | | | | | | | | | | 0.30 | | | |
| Columbia, S. C. | 5 | | | 0.42 | | | | | | | | | | | | | | 0.42 | | | |
| Columbus, Ohio. | 23 | | | 2.05 | | | | | | | | | | | | | | 0.35 | | | |
| Concord, N. H | 24 | | | 1.04 | | | | | | | | | | | | | | * | | | |
| Concordia, Kans | 22 | | | 0.39 | | | | | | | | | | | | | | 0.16 | | | |
| Corpus Christi, Tex | 14 | | | 0.08 | | | | | | | | | | | | | | 0.08 | | | |
| Davenport, Iowa | 8–9 | | | 0.84 | | | | | | | | | | | | | | * | | | |
| Del Rio, Tex. | 28 | | | 0.30 | | | | | | | | | | | | | | 0.30 | | | |
| Denver, Colo | 22 | | | 0.88 | | | | | | | | | | | | | | * | | | |
| Des Moines, Iowa | 8–9 | | | 0.42 | | | | | | | | | | | | | | * | | | |
| Detroit, Mich. | 23 | | | | | | | | | | | | | | | | | 0.38 | | | |
| Devils Lake, N. Dak | 17 | | | 0.16 | | | | | | | | | | | | | | * | | | |
| Dodge City, Kans. | 18 | | | 0.08 | | | | | | | | | | | | | | * | | | |
| Dubuque, Iowa. | 8–9 | | | 1.50 | | | | | | | | | | | | | | * | | | |
| Duluth, Minn. | 9–10 | | | 0.66 | | | | | | | | | | | | | | * | | | |
| Durango, Colo. | 21–22 | | | 0.82 | | | | | | | | | | | | | | * | | | |
| Eastport, Me. | 10 | | | 1.13 | | | | | | | | | | | | | | 0.26 | | | |
| Elkins, W. Va. | 15 | | | 0.29 | | | | | | | | | | | | | | 0.22 | | | |
| El Paso, Tex. | 22 | | | 0.12 | | | | | | | | | | | | | | * | | | |
| Erie, Pa. | 14–15 | | | 1.57‡ | | | | | | | | | | | | | | * | | | |

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, etc.*—Continued.

| Stations. | Date. | Total duration. From— | Total duration. To— | Total amount of precipitation. | Excessive rate. Began— | Excessive rate. Ended— | Amount before excessive began. | 5 min. | 10 min. | 15 min. | 20 min. | 25 min. | 30 min. | 35 min. | 40 min. | 45 min. | 50 min. | 60 min. | 80 min. | 100 min. | 120 min. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Escanaba, Mich | 9-10 | | | 1.51 | | | | | | | | | | | | | | | | | |
| Eureka, Cal | 2 | | | 1.64 | | | | | | | | | | | | | | * | | | |
| Evansville, Ind | 14 | | | 1.72 | | | | | | | | | | | | | | * | | | |
| Flagstaff, Ariz | 21 | | | 1.01 | | | | | | | | | | | | | | 0.49 | | | |
| Fort Smith, Ark | 22-23 | 2:50 p. m. | D. N. | 1.39 | 4:47 p. m. | 4:53 p. m. | 0.03 | 0.29 | 0.33 | | | | | | | | | * | | | |
| | | | | | 6:27 p. m. | 6:41 p. m. | 0.74 | 0.06 | 0.32 | 0.47 | | | | | | | | | | | |
| Fort Worth, Tex | 13 | | | 0.09 | | | | | | | | | | | | | | | | | |
| Fresno, Cal | 3 | | | 0.55 | | | | | | | | | | | | | | 0.08 | | | |
| Galveston, Tex | 14 | | | 0.90 | | | | | | | | | | | | | | 0.13 | | | |
| Grand Haven, Mich | 5 | | | 1.16 | | | | | | | | | | | | | | 0.68 | | | |
| Grand Junction, Colo | 17 | | | 0.20 | | | | | | | | | | | | | | 0.22 | | | |
| Grand Rapids, Mich | 5 | | | 1.07 | | | | | | | | | | | | | | * | | | |
| Green Bay, Wis | 8-9 | | | 0.44 | | | | | | | | | | | | | | 0.19 | | | |
| Greenville, Me | 19-20 | | | 1.24 | | | | | | | | | | | | | | * | | | |
| Hannibal, Mo | 22 | | | 0.75 | | | | | | | | | | | | | | * | | | |
| Harrisburg, Pa | 19 | | | 0.91 | | | | | | | | | | | | | | 0.50 | | | |
| Hartford, Conn | 23-24 | | | 1.47 | | | | | | | | | | | | | | 0.43 | | | |
| Hatteras, N. C | 19 | 4:55 p. m. | 8:25 p. m. | 0.52 | 5:43 p. m. | 5:55 p. m. | 0.05 | 0.16 | 0.33 | 0.36 | | | | | | | | * | | | |
| Havre, Mont | 24-25 | | | 0.29 | | | | | | | | | | | | | | | | | |
| Helena, Mont | 16 | | | 0.17 | | | | | | | | | | | | | | * | | | |
| Houghton, Mich | 9-10 | | | 0.60 | | | | | | | | | | | | | | * | | | |
| Huron, S. Dak | 8-9 | | | 0.87 | | | | | | | | | | | | | | * | | | |
| Independence, Cal | 10-11 | | | 1.34 | | | | | | | | | | | | | | * | | | |
| Indianapolis, Ind | 16 | | | 0.21 | | | | | | | | | | | | | | * | | | |
| Iola, Kans | 13-14 | | | 0.78 | | | | | | | | | | | | | | * | | | |
| Jacksonville, Fla | 10 | | | 0.42 | | | | | | | | | | | | | | * | | | |
| Jupiter, Fla | 15 | | | 0.24 | | | | | | | | | | | | | | 0.33 | | | |
| Kalispell, Mont | 7 | | | 0.36 | | | | | | | | | | | | | | 0.14 | | | |
| Kansas City, Mo | 22 | | | 0.53 | | | | | | | | | | | | | | * | | | |
| Keokuk, Iowa | 18-19 | | | 0.57 | | | | | | | | | | | | | | 0.25 | | | |
| Key West, Fla | 15 | | | 0.08 | | | | | | | | | | | | | | * | | | |
| Knoxville, Tenn | 21 | 1:30 p. m. | 3:05 p. m. | 0.46 | 1:42 p. m. | 1:48 p. m. | 0.02 | 0.30 | | | | | | | | | | 0.08 | | | |
| La Crosse, Wis | 22-23 | | | 0.79 | | | | | | | | | | | | | | | | | |
| Lander, Wyo | 7-8 | | | 0.60 | | | | | | | | | | | | | | * | | | |
| La Salle, Ill | 8-9 | | | 0.82 | | | | | | | | | | | | | | * | | | |
| Lewiston, Idaho | 16 | | | 0.21 | | | | | | | | | | | | | | * | | | |
| Lexington, Ky | 23 | | | 2.99 | | | | | | | | | | | | | | 0.07 | | | |
| Lincoln, Nebr | 22 | | | 0.72 | | | | | | | | | | | | | | 0.66 | | | |
| Little Rock, Ark | 13-14 | 7:10 p. m. | 2:45 p. m. | 1.79 | 1:43 a. m. | 2:03 a. m. | 0.26 | 0.16 | 0.34 | 0.47 | 0.56 | | | | | | | * | | | |
| Do | 23 | D. N. | 8:00 a. m. | 2.07 | 3:00 a. m. | 4:00 a. m. | 0.51 | 0.14 | 0.29 | 0.42 | 0.53 | 0.62 | 0.70 | 0.74 | 0.74 | 0.81 | 0.92 | | | | |
| Los Angeles, Cal | 12 | | | 0.68 | | | | | | | | | | | | | | 1.09 | | | |
| Louisville, Ky | 22-23 | | | 5.00 | 4:23 a. m. | 4:58 a. m. | 0.24 | 0.08 | 0.28 | 0.47 | 0.63 | 0.75 | 0.91 | 1.00 | | | | 0.46 | | | |
| Lynchburg, Va | 19 | | | 0.59 | | | | | | | | | | | | | | | | | |
| Macon, Ga | 9-10 | 3:05 p. m. | D. N. | 3.88 | 5:07 p. m. | 6:15 p. m. | 0.27 | 0.09 | 0.20 | 0.31 | 0.11 | 0.45 | 0.48 | 0.59 | 0.70 | 0.78 | 0.82 | 0.31 | | | |
| | | | | | 7:10 p. m. | 7:52 p. m. | 1.65 | 0.06 | 0.13 | 0.23 | 0.27 | 0.32 | 0.41 | 0.60 | 0.67 | 0.72 | | 0.99 | | | |
| | | | | | 8:50 p. m. | 9:10 p. m. | 2.60 | 0.10 | 0.24 | 0.31 | 0.42 | | | | | | | | | | |
| Do | 21 | 8:15 p. m. | D. N. | 0.41 | 10:55 p. m. | 11:05 p. m. | 0.08 | 0.23 | 0.32 | | | | | | | | | | | | |
| Madison, Wis | 13-14 | | | 0.66 | | | | | | | | | | | | | | | | | |
| Marquette, Mich | 23-24 | | | 1.18 | | | | | | | | | | | | | | * | | | |
| Memphis, Tenn | 23 | 7:35 a. m. | 5:35 p. m. | 2.02 | 8:38 a. m. | 8:52 a. m. | 0.22 | 0.11 | 0.33 | 0.45 | | | | | | | | * | | | |
| | | | | | 11:53 a. m. | 12:25 p. m. | 0.96 | 0.18 | 0.28 | 0.34 | 0.44 | 0.59 | 0.86 | 0.95 | | | | | | | |
| Meridian, Miss | 9 | 11:02 a. m. | 12:40 p. m. | 0.73 | 11:40 a. m. | 12:00 m. | 0.08 | 0.12 | 0.29 | 0.45 | 0.53 | | | | | | | | | | |
| Milwaukee, Wis | 14-15 | | | 0.98 | | | | | | | | | | | | | | | | | |
| Minneapolis, Minn | 9-10 | | | 0.81‡ | | | | | | | | | | | | | | * | | | |
| Mobile, Ala | 5 | 4:55 p. m. | 5:45 p. m. | 0.56 | 5:08 p. m. | 5:19 p. m. | 0.03 | 0.40 | 0.48 | 0.52 | | | | | | | | * | | | |
| Do | 9 | 5:05 p. m. | 7:50 p. m. | 0.93 | 5:50 p. m. | 6:04 p. m. | 0.03 | 0.18 | 0.38 | 0.43 | | | | | | | | | | | |
| Do | 19 | D. N. | D. N. | 0.48 | 1:18 a. m. | 1:29 a. m. | 0.06 | 0.20 | 0.38 | 0.40 | | | | | | | | | | | |
| Modena, Utah | 7-8 | | | 0.32 | | | | | | | | | | | | | | * | | | |
| Montgomery, Ala | 9 | 10:43 a. m. | 8:37 p. m. | 4.35 | 1:10 p. m. | 2:19 p. m. | 0.13 | 0.05 | 0.14 | 0.27 | 0.50 | 0.58 | 0.65 | 0.68 | 0.76 | 0.83 | 0.89 | 0.92 | 1.18 | | |
| | | | | | 2:45 p. m. | 3:42 p. m. | 1.38 | 0.13 | 0.17 | 0.22 | 0.50 | 0.77 | 0.83 | 0.90 | 1.01 | 1.08 | 1.17 | 1.48 | | | |
| Moorhead, Minn | 9 | | | 0.18 | | | | | | | | | | | | | | | | | |
| Mount Tamalpais, Cal | 11 | | | 1.60 | | | | | | | | | | | | | | * | | | |
| Mount Weather, Va | 19 | | | 0.71 | | | | | | | | | | | | | | 0.31 | | | |
| Nantucket, Mass | 16 | | | 1.21 | | | | | | | | | | | | | | 0.39 | | | |
| Nashville, Tenn | 23 | 9:20 a. m. | 11:55 p. m. | 3.69 | 1:03 p. m. | 1:45 p. m. | 0.58 | 0.31 | 0.35 | 0.43 | 0.55 | 0.65 | 0.72 | 0.80 | 0.87 | 0.90 | | 0.50 | | | |
| | | | | | 7:09 p. m. | 7:19 p. m. | 3.04 | 0.28 | 0.36 | | | | | | | | | | | | |
| New Haven, Conn | 10 | | | 2.06 | | | | | | | | | | | | | | | | | |
| New Orleans, La | 9 | 10:30 a. m. | 5:25 p. m. | 2.55 | 11:13 a. m. | 11:37 a. m. | 0.03 | 0.12 | 0.14 | 0.28 | 0.45 | 0.58 | | | | | | 0.52 | | | |
| | | | | | 3:32 p. m. | 4:22 p. m. | 1.50 | 0.12 | 0.18 | 0.20 | 0.28 | 0.37 | 0.43 | 0.60 | 0.67 | 0.70 | 0.86 | | | | |
| New York, N. Y | 23-24 | | | 1.56 | | | | | | | | | | | | | | | | | |
| Norfolk, Va | 16 | | | 0.63 | | | | | | | | | | | | | | 0.25 | | | |
| Northfield, Vt | 19-20 | | | 1.26 | | | | | | | | | | | | | | 0.38 | | | |
| North Head, Wash | 1 | | | 1.78 | | | | | | | | | | | | | | * | | | |
| North Platte, Nebr | 22 | | | 1.15 | | | | | | | | | | | | | | 0.22 | | | |
| Oklahoma, Okla | 13 | | | 0.44 | | | | | | | | | | | | | | * | | | |
| Omaha, Nebr | 8-9 | | | 0.57 | | | | | | | | | | | | | | 0.35 | | | |
| Oswego, N. Y | 15-16 | | | 0.95 | | | | | | | | | | | | | | * | | | |
| Palestine, Tex | 9 | 2:30 a. m. | 3:18 a. m. | 0.83 | 2:33 a. m. | 2:48 a. m. | T. | 0.30‡ | 0.60‡ | 0.76‡ | | | | | | | | * | | | |
| Parkersburg, W. Va | 23 | | | 2.64 | | | | | | | | | | | | | | | | | |
| Pensacola, Fla | 9 | 8:05 p. m. | 10:30 p. m. | 0.94 | 8:37 p. m. | 9:32 p. m. | 0.08 | 0.11 | 0.21 | 0.26 | 0.32 | 0.37 | 0.53 | 0.58 | 0.67 | 0.69 | 0.77 | 0.46 | | | |
| Do | 13 | 8:05 p. m. | 10:15 p. m. | 1.02 | 8:40 p. m. | 9:20 p. m. | 0.03 | 0.09 | 0.28 | 0.34 | 0.36 | 0.56 | 0.78 | 0.91 | 0.98 | | | 0.85 | | | |
| Peoria, Ill | 8-9 | | | 1.00 | | | | | | | | | | | | | | | | | |
| Philadelphia, Pa | 23 | | | 1.65 | | | | | | | | | | | | | | * | | | |
| Phoenix, Ariz | 21 | | | 0.48 | | | | | | | | | | | | | | 0.38 | | | |
| Pierre, S. Dak | 8-9 | | | 0.38 | | | | | | | | | | | | | | 0.25 | | | |
| Pittsburg, Pa | 23-24 | | | 1.40 | | | | | | | | | | | | | | * | | | |
| Pocatello, Idaho | 8 | | | 1.07 | | | | | | | | | | | | | | * | | | |
| Point Reyes Light, Cal | 11 | | | 0.96 | | | | | | | | | | | | | | * | | | |
| Port Huron, Mich | 23 | | | 0.59 | | | | | | | | | | | | | | 0.27 | | | |
| Portland, Me | 23-24 | | | 1.33 | | | | | | | | | | | | | | 0.22 | | | |
| Portland, Oreg | 16 | | | 0.83 | | | | | | | | | | | | | | 0.23 | | | |
| Providence, R. I | 24 | | | 1.55 | | | | | | | | | | | | | | 0.27 | | | |
| Pueblo, Colo | 13-14 | | | 0.40 | | | | | | | | | | | | | | 0.34 | | | |
| Raleigh, N. C | 10 | | | 0.74 | | | | | | | | | | | | | | * | | | |
| Rapid City, S. Dak | 7-8 | | | 0.17 | | | | | | | | | | | | | | 0.30 | | | |
| Red Bluff, Cal | 2 | | | 3.69 | | | | | | | | | | | | | | * | | | |
| Reno, Nev | 11 | | | 0.45 | | | | | | | | | | | | | | 0.38 | | | |
| Richmond, Va | 16 | | | 0.32 | | | | | | | | | | | | | | * | | | |
| Rochester, N. Y | 15-16 | | | 1.00 | | | | | | | | | | | | | | 0.25 | | | |
| Roseburg, Oreg | 19 | | | 0.54 | | | | | | | | | | | | | | * | | | |
| Roswell, N. Mex | 14 | | | 0.02 | | | | | | | | | | | | | | 0.18 | | | |
| Sacramento, Cal | 12 | | | 1.12 | | | | | | | | | | | | | | 0.02 | | | |
| St. Louis, Mo | 13-14 | | | 0.98 | | | | | | | | | | | | | | 0.35 | | | |
| St. Paul, Minn | 8-9 | | | 0.90 | | | | | | | | | | | | | | * | | | |
| | | | | | | | | | | | | | | | | | | * | | | |

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, etc.*—Continued.

| Stations. | Date. | Total duration. From— | Total duration. To— | Total amount of precipitation. | Excessive rate. Began— | Excessive rate. Ended— | Amount before excessive began. | Depths of precipitation (in inches) during periods of time indicated. 5 min. | 10 min. | 15 min. | 20 min. | 25 min. | 30 min. | 35 min. | 40 min. | 45 min. | 50 min. | 60 min. | 80 min. | 100 min. | 120 min. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Salt Lake City, Utah | 13 | | | 0.76 | | | | | | | | | | | | | | * | | | |
| San Antonio, Tex | 14 | | | 0.70 | | | | | | | | | | | | | | 0.70 | | | |
| San Diego, Cal | 20 | | | 0.55 | | | | | | | | | | | | | | 0.17 | | | |
| Sand Key, Fla | 6–7 | 10:30 p. m. | 2:30 a. m. | 0.87 | 12:19 a. m. | 12:48 a. m. | 0.31 | 0.09 | 0.18 | 0.30 | 0.38 | 0.49 | 0.55 | | | | | | | | |
| Sandusky, Ohio | 14–15 | | | 1.50 | | | | | | | | | | | | | | * | | | |
| San Francisco, Cal | 7 | | | 0.73 | | | | | | | | | | | | | | 0.30 | | | |
| San Jose, Cal | 10 | | | 0.68 | | | | | | | | | | | | | | 0.20 | | | |
| San Luis Obispo, Cal | 7 | | | 0.62 | | | | | | | | | | | | | | 0.60 | | | |
| Santa Fe, N. Mex | 21 | | | 0.26 | | | | | | | | | | | | | | * | | | |
| Sault Sainte Marie, Mich | 18–19 | | | 0.48 | | | | | | | | | | | | | | * | | | |
| Savannah, Ga | 15 | | | 0.46 | | | | | | | | | | | | | | 0.30 | | | |
| Scranton, Pa | 23 | | | 0.70 | | | | | | | | | | | | | | 0.14 | | | |
| Seattle, Wash | 24 | | | 0.27 | | | | | | | | | | | | | | 0.14 | | | |
| Sheridan, Wyo | 16–17 | | | 0.17 | | | | | | | | | | | | | | * | | | |
| Shreveport, La | 14 | 2:15 a. m. | 12:40 p. m. | 1.75 | 2:15 a. m. | 2:45 a. m. | 0.00 | 0.14 | 0.18 | 0.33 | 0.40 | 0.47 | 0.53 | | | | | | | | |
| Sioux City, Iowa | 8–9 | | | 1.15 | | | | | | | | | | | | | | * | | | |
| Southeast Farallon, Cal | 2 | | | 1.78 | | | | | | | | | | | | | | 0.27 | | | |
| Spokane, Wash | 6 | | | 0.33 | | | | | | | | | | | | | | * | | | |
| Springfield, Ill | 13–14 | | | 1.75 | | | | | | | | | | | | | | * | | | |
| Springfield, Mo | 14–15 | | | 0.38 | | | | | | | | | | | | | | * | | | |
| Syracuse, N. Y | 15–16 | | | 1.95 | | | | | | | | | | | | | | * | | | |
| Tacoma, Wash | 24 | | | 0.44 | | | | | | | | | | | | | | 0.15 | | | |
| Tampa, Fla | 19 | | | 0.25 | | | | | | | | | | | | | | 0.25 | | | |
| Tatoosh Island, Wash | 15 | | | 1.18 | | | | | | | | | | | | | | 0.32 | | | |
| Taylor, Tex | 14 | | | 0.61 | | | | | | | | | | | | | | 0.29 | | | |
| Thomasville, Ga | 9–10 | 11:45 p. m. | 2:30 a. m. | 0.66 | 1:59 a. m. | 2:11 a. m. | 0.15 | 0.24 | 0.45 | 0.47 | | | | | | | | | | | |
| Do | 15 | 1:02 p. m. | 8:10 p. m. | 0.97 | 1:07 p. m. | 1:52 p. m. | 0.01 | 0.14 | 0.16 | 0.16 | 0.31 | 0.36 | 0.43 | 0.48 | 0.59 | 0.71 | | | | | |
| Toledo, Ohio | 23 | | | 1.40 | | | | | | | | | | | | | | 0.57 | | | |
| Tonopah, Nev | 7 | | | 0.16 | | | | | | | | | | | | | | * | | | |
| Topeka, Kans | 13 | | | 0.25 | | | | | | | | | | | | | | 0.15 | | | |
| Valentine, Nebr | 22 | | | 0.52 | | | | | | | | | | | | | | * | | | |
| Vicksburg, Miss | 9 | D. N. | D. N. | 0.99 | 2:28 a. m. | 2:52 a. m. | 0.25 | 0:10 | 0.14 | 0.46 | 0.67 | 0.74 | | | | | | | | | |
| Do | 9 | 7:10 a. m. | 11:45 a. m. | 1.05 | 7:41 a. m. | 8:01 a. m. | 0.03 | 0.17 | 0.40 | 0.51 | 0.67 | | | | | | | | | | |
| Do | 23 | 9:00 a. m. | 11:40 a. m. | 0.80 | 10:22 a. m. | 10:34 a. m. | 0.10 | 0.21 | 0.50 | 0.55 | | | | | | | | | | | |
| Walla Walla, Wash | 27–28 | | | 0.93 | | | | | | | | | | | | | | * | | | |
| Washington, D. C | 23 | | | 0.40 | | | | | | | | | | | | | | 0.20 | | | |
| Wichita, Kans | 22 | | | 0.36 | | | | | | | | | | | | | | 0.36 | | | |
| Williston, N. Dak | 6–7 | | | 0.06 | | | | | | | | | | | | | | * | | | |
| Wilmington, N. C | 16 | | | 1.31 | | | | | | | | | | | | | | 0.43 | | | |
| Winnemucca, Nev | 20 | | | 0.39 | | | | | | | | | | | | | | * | | | |
| Wytheville, Va | 9 | | | 0.53 | | | | | | | | | | | | | | 0.14 | | | |
| Yankton, S. Dak | 22–23 | | | 1.05 | | | | | | | | | | | | | | * | | | |
| Yellowstone Park, Wyo | 7–8 | | | 0.34 | | | | | | | | | | | | | | * | | | |

* Self register not working. † No precipitation recorded during month. ‡ Partly estimated

TABLE III.—*Data furnished by the Canadian Meteorological Service, February, 1909.*

| Stations. | Pressure. | | | Temperature. | | | | Precipitation. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Actual, reduced to mean of 24 hours. | Sea level, reduced to mean of 24 hours. | Departure from normal. | Mean. | Departure from normal. | Mean maximum. | Mean minimum. | Total. | Departure from normal. | Total snowfall. |
| | Ins. | Ins. | Ins. | ° | ° | ° | ° | Ins. | Ins. | Ins. |
| St. Johns, N. F | 29.64 | 29.78 | —.05 | 23.5 | + 1.5 | 31.3 | 15.7 | 4.41 | —0.50 | 25.7 |
| Sydney, C. B. I | 29.83 | 29.87 | —.05 | 20.5 | + 1.2 | 30.0 | 10.9 | 4.16 | +0.07 | 13.0 |
| Halifax, N. S | 29.78 | 29.89 | —.06 | 23.4 | + 1.0 | 32.4 | 14.5 | 4.88 | —0.28 | 9.6 |
| Grand Manan, N. B | 29.82 | 29.88 | —.10 | 24.8 | + 1.4 | 33.5 | 16.2 | 3.16 | —0.81 | 6.0 |
| Yarmouth, N. S | 29.82 | 29.89 | —.10 | 26.9 | + 1.1 | 34.5 | 19.4 | 3.38 | —1.36 | 6.7 |
| Charlottetown, P. E. I | 29.80 | 29.84 | —.11 | 19.0 | + 1.4 | 27.6 | 10.3 | 3.65 | +0.59 | 13.0 |
| Chatham, N. B | 29.83 | 29.86 | —.10 | 14.0 | + 1.5 | 24.4 | 3.6 | 2.60 | —0.56 | 16.8 |
| Father Point, Que | 29.84 | 29.87 | —.11 | 9.1 | — 2.4 | 18.3 | — 0.1 | 1.07 | —1.14 | 10.7 |
| Quebec, Que | 29.55 | 29.89 | —.10 | 11.4 | — 0.4 | 19.7 | 3.0 | 5.66 | +2.39 | 34.4 |
| Montreal, Que | 29.69 | 29.91 | —.11 | 16.5 | + 2.0 | 24.3 | 8.7 | 4.06 | +0.99 | 18.6 |
| Rockliffe, Ont. | 29.29 | 29.93 | —.08 | 9.9 | 0.0 | 23.1 | — 3.2 | 1.24 | —0.76 | 10.4 |
| Ottawa, Ont | 29.67 | 30.01 | —.01 | 16.3 | + 4.6 | 24.7 | 7.8 | 3.07 | +0.38 | 18.6 |
| Kingston, Ont | 29.63 | 29.97 | —.07 | 22.0 | + 4.2 | 30.1 | 13.9 | 4.20 | +1.66 | 13.0 |
| Toronto, Ont | 29.53 | 29.93 | —.11 | 26.7 | + 5.2 | 33.7 | 19.7 | 3.17 | +0.56 | 15.5 |
| White River, Ont | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| Port Stanley, Ont | 29.31 | 29.97 | —.09 | 27.5 | + 4.7 | 33.9 | 21.1 | 4.34 | +1.13 | 21.8 |
| Southampton, Ont | 29.19 | ...... | ...... | 25.1 | + 5.2 | 32.9 | 17.4 | 4.58 | +1.68 | 29.5 |

| Stations. | Pressure. | | | Temperature. | | | | Precipitation. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Actual, reduced to mean of 24 hours. | Sea level, reduced to mean of 24 hours. | Departure from normal. | Mean. | Departure from normal. | Mean maximum. | Mean minimum. | Total. | Departure from normal. | Total snowfall. |
| | Ins. | Ins. | Ins. | ° | ° | ° | ° | Ins. | Ins. | Ins. |
| Parry Sound, Ont | 29.19 | 29.92 | —.09 | 18.2 | + 3.9 | 27.8 | 8.5 | 4.73 | +1.81 | 29.5 |
| Port Arthur, Ont | 29.26 | 30.00 | —.02 | 9.4 | + 3.0 | 20.7 | — 2.0 | 0.56 | —0.34 | 5.3 |
| Winnipeg, Man | 29.21 | 30.11 | +.01 | 0.3 | + 1.9 | 10.2 | — 9.6 | 0.76 | —0.22 | 7.6 |
| Minnedosa, Man | 28.10 | 30.04 | —.05 | 0.0 | + 2.7 | 10.3 | —10.3 | 1.85 | +1.24 | 18.5 |
| Qu' Appelle, Assin | 27.60 | 29.98 | —.10 | 2.2 | + 2.8 | 10.6 | — 6.3 | 0.54 | —0.19 | 5.4 |
| Medicine Hat, Alberta | 27.60 | 29.98 | —.07 | 14.2 | + 3.0 | 24.1 | 4.3 | 0.35 | —0.32 | 3.0 |
| Swift Current, Sask | 27.30 | 30.02 | —.05 | 8.2 | + 0.2 | 17.0 | — 0.7 | 0.24 | —0.50 | 2.4 |
| Calgary, Alberta | 26.23 | 29.94 | —.05 | 11.8 | — 1.7 | 22.4 | 1.2 | 0.36 | —0.27 | 3.6 |
| Banff, Alberta | 25.14 | 29.92 | —.06 | 15.5 | — 3.7 | 25.0 | 6.1 | 1.38 | +0.46 | 13.8 |
| Edmonton, Alberta | 27.56 | 29.98 | —.04 | 5.9 | — 2.4 | 16.1 | — 4.4 | 0.49 | —0.18 | 4.9 |
| Prince Albert, Sask | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| Battleford, Sask | 28.19 | 30.05 | —.04 | —2.1 | — 2.2 | 6.1 | —10.4 | 0.02 | —0.35 | 0.2 |
| Kamloops, B. C | 28.50 | 29.79 | —.17 | 29.4 | + 1.1 | 35.9 | 22.9 | 1.00 | +0.21 | 0.0 |
| Victoria, B. C | 29.72 | 29.82 | —.18 | 41.4 | + 1.9 | 45.9 | 36.8 | 2.20 | —1.90 | 0.0 |
| Barkerville, B. C | 25.32 | 29.71 | —.20 | 17.0 | — 1.9 | 24.8 | 9.3 | 3.72 | +0.66 | 0.0 |
| Hamilton, Bermuda | 30.04 | 30.21 | +.10 | 61.9 | + 0.4 | 67.0 | 56.8 | 4.26 | —0.18 | 0.0 |
| Dawson, Yukon | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |

TABLE IV.—*Heights of rivers referred to zeros of gages, February, 1909.*

| Stations. | Distance to mouth of river. | Flood stage on gage. | Highest water. | | Lowest water. | | Mean stage. | Monthly range. |
|---|---|---|---|---|---|---|---|---|
| | | | Height. | Date. | Height. | Date. | | |
| *Republican River.* | Miles. | Feet. | Feet. | | Feet. | | Feet. | Feet. |
| Clay Center, Kans. (12) | 42 | 18 | 7.0 | 28 | 6.3 | 3, 4 | 6.6 | 0.7 |
| *Smoky Hill-Kansas River.* | | | | | | | | |
| Abilene, Kans. | 254 | 22 | 1.6 | 28 | 0.4 | 12 | 0.9 | 1.2 |
| Manhattan, Kans. | 160 | 18 | 3.9 | 28 | 1.8 | 10, 11 | 3.0 | 2.1 |
| Topeka, Kans. (6) | 87 | 21 | 7.9 | 24 | 5.6 | 13 | 6.3 | 2.3 |
| *Missouri River.* | | | | | | | | |
| Bismarck, N. Dak. | 1,309 | 14 | 4.8 | 27,28 | 3.3 | 1 | 4.0 | 1.5 |
| Pierre, S. Dak. (28) | 1,114 | 14 | ...... | ...... | ...... | ...... | ...... | ...... |
| Sioux City, Iowa | 784 | 17 | 8.9 | 1 | 6.7 | 13 | 7.8 | 2.2 |
| Blair, Nebr | 705 | 15 | 9.8 | 28 | 7.5 | 14–16 | 8.6 | 2.3 |
| Omaha, Nebr. (28) | 669 | 18 | ...... | ...... | ...... | ...... | ...... | ...... |
| St. Joseph, Mo. | 481 | 10 | 7.1 | 19 | 0.5 | 12 | 2.2 | 6.6 |
| Kansas City, Mo. | 388 | 21 | 9.7 | 21 | 5.2 | 12 | 7.3 | 4.5 |
| Glasgow, Mo. | 231 | 21 | 11.7 | 24 | 6.8 | 19 | 9.2 | 4.9 |
| Boonville, Mo. | 199 | 20 | 12.2 | 25, 26 | 6.8 | 17 | 9.6 | 5.4 |
| Hermann, Mo | 103 | 24 | 12.7 | 24 | 6.2 | 6 | 8.8 | 6.5 |
| *Minnesota River.* | | | | | | | | |
| Mankato, Minn | 127 | 18 | 4.2 | 5 | 2.9 | 13–21 | 3.3 | 1.3 |
| *St. Croix River.* | | | | | | | | |
| Stillwater, Minn. (28) | 23 | 11 | ...... | ...... | ...... | ...... | ...... | ...... |
| *Illinois River.* | | | | | | | | |
| La Salle, Ill. | 197 | 18 | 21.6 | 21 | 13.7 | 1 | 17.5 | 7.9 |
| Peoria, Ill. | 135 | 14 | 15.7 | 28 | 9.2 | 4 | 11.1 | 6.5 |
| *Conemaugh River.* | | | | | | | | |
| Johnstown, Pa | 64 | 7 | 8.3 | 24 | 1.6 | 4 | 3.2 | 6.7 |
| *Allegheny River.* | | | | | | | | |
| Warren, Pa. | 177 | 14 | 9.0 | 25 | 1.1 | 4 | 4.6 | 7.9 |
| Parker, Pa. | 73 | 20 | 13.0 | 25 | 1.9 | 5 | 6.4 | 11.1 |
| Freeport, Pa. | 29 | 20 | 20.8 | 25 | 4.0 | 4 | 10.9 | 16.8 |
| Springdale, Pa | 17 | 27 | 25.0 | 25 | 10.6 | 5 | 16.0 | 14.4 |
| *Youghiogheny River.* | | | | | | | | |
| Confluence, Pa. (5) | 59 | 10 | 6.5 | 24 | 1.5 | 9, 10 | 2.9 | 5.0 |
| West Newton, Pa. | 15 | 23 | 11.0 | 24 | 0.5 | 3 | 3.5 | 10.5 |
| *Monongahela River.* | | | | | | | | |
| Fairmont, W. Va. (4) | 119 | 25 | 21.2 | 16 | 14.9 | 5 | 16.9 | 6.3 |
| Greensboro, Pa. | 81 | 18 | 15.8 | 24 | 7.4 | 2, 3 | 10.2 | 8.4 |
| Lock No. 4, Pa. | 40 | 28 | 22.5 | 24 | 10.0 | 2–4, 9 | 12.9 | 12.5 |
| *Muskingum River.* | | | | | | | | |
| Zanesville, Ohio | 70 | 25 | 26.0 | 25 | 9.4 | 2 | 15.0 | 16.6 |
| *Little Kanawha River.* | | | | | | | | |
| Creston, W. Va. | 38 | 20 | 15.0 | 17 | 3.2 | 2 | 5.7 | 11.8 |
| *New-Great Kanawha River.* | | | | | | | | |
| Hinton, W. Va. | 153 | 14 | 5.5 | 11 | 2.0 | 2 | 3.7 | 3.5 |
| Charleston, W. Va. | 58 | 30 | 11.2 | 17 | 3.8 | 3 | 7.9 | 7.4 |
| *Scioto River.* | | | | | | | | |
| Columbus, Ohio (4) | 110 | 17 | 18.7 | 24 | 1.6 | 5–12 | 5.7 | 17.1 |
| *Licking River.* | | | | | | | | |
| Falmouth, Ky. | 30 | 25 | 37.8 | 24 | 2.4 | 1 | 10.2 | 35.4 |
| *Kentucky River.* | | | | | | | | |
| Beattyville, Ky | 254 | 30 | 20.0 | 25 | 0.6 | 5 | 4.7 | 19.4 |
| Frankfort, Ky. | 65 | 31 | 34.3 | 25 | 6.4 | 4 | 11.7 | 27.9 |
| *Wabash River.* | | | | | | | | |
| Terre Haute, Ind. | 171 | 16 | 17.8 | 28 | 0.9 | 4, 5 | 7.5 | 16.9 |
| Mount Carmel, Ill. (5) | 75 | 15 | 18.2 | 28 | 1.7 | 6 | 8.8 | 16.5 |
| *Cumberland River.* | | | | | | | | |
| Burnside, Ky. | 518 | 50 | 41.3 | 25 | 2.7 | 4 | 13.0 | 38.6 |
| Celina, Tenn. | 383 | 45 | 36.9 | 27 | 4.3 | 5 | 17.3 | 32.6 |
| Carthage, Tenn. | 308 | 40 | 40.7 | 26 | 3.8 | 5 | 16.0 | 36.9 |
| Nashville, Tenn | 193 | 40 | 40.0 | 28 | 9.8 | 5 | 21.3 | 30.2 |
| Clarksville, Tenn. | 126 | 43 | 45.6 | 26 | 7.6 | 5 | 23.0 | 38.0 |
| *Clinch River.* | | | | | | | | |
| Speers Ferry, Va. | 156 | 20 | 8.0 | 10 | 0.8 | 5 | 3.2 | 7.2 |
| Clinton, Tenn | 52 | 25 | 18.4 | 12 | 5.3 | 5 | 11.0 | 13.1 |
| *South Fork Holston River.* | | | | | | | | |
| Bluff City, Tenn. (1) | 35 | 12 | 4.9 | 11 | 1.5 | 3–5 | 2.7 | 3.4 |
| *Holston River.* | | | | | | | | |
| Rogersville, Tenn. | 103 | 14 | 7.4 | 11 | 2.4 | 2 | 4.1 | 5.0 |

| Stations. | Distance to mouth of river. | Flood stage on gage. | Highest water. | | Lowest water. | | Mean stage. | Monthly range. |
|---|---|---|---|---|---|---|---|---|
| | | | Height. | Date. | Height. | Date. | | |
| *French Broad River.* | Miles. | Feet. | Feet. | | Feet. | | Feet. | Feet. |
| Asheville, N. C. | 144 | 4 | 2.8 | 25 | 0.2 | 4, 5 | 1.1 | 2.6 |
| Dandridge, Tenn. (3) | 46 | 12 | 6.8 | 25 | 1.6 | 5 | 4.0 | 5.2 |
| *Tennessee River.* | | | | | | | | |
| Knoxville, Tenn. | 635 | 12 | 9.0 | 11 | 1.9 | 3 | 5.0 | 7.1 |
| Loudon, Tenn | 590 | 25 | 10.5 | 24 | 1.0 | 3, 4 | 5.4 | 9.5 |
| Kingston, Tenn. | 556 | 25 | 13.1 | 25 | 3.3 | 4, 5 | 8.0 | 9.8 |
| Chattanooga, Tenn. | 452 | 33 | 21.6 | 25 | 5.4 | 5 | 13.2 | 16.2 |
| Bridgeport, Ala | 402 | 24 | 18.2 | 26 | 3.0 | 5 | 13.6 | 15.2 |
| Guntersville, Ala. | 349 | 31 | 26.8 | 26 | 6.2 | 5, 6 | 17.1 | 20.6 |
| Florence, Ala. | 255 | 16 | 19.5 | 24 | 3.2 | 6 | 11.1 | 16.3 |
| Riverton, Ala. | 225 | 32 | 39.5 | 26 | 12.2 | 5 | 25.3 | 27.3 |
| Johnsonville, Tenn. | 95 | 21 | 32.9 | 28 | 6.0 | 5 | 18.1 | 26.9 |
| *Ohio River.* | | | | | | | | |
| Pittsburg, Pa. | 966 | 22 | 22.3 | 25 | 1.6 | 3 | 9.5 | 20.7 |
| Coraopolis, Pa. | 956 | 25 | 22.4 | 25 | 3.3 | 4 | 10.2 | 19.1 |
| Beaver Dam, Pa. | 937 | 27 | 32.5 | 25 | 6.0 | 4 | 15.8 | 26.5 |
| Wheeling, W. Va. | 875 | 36 | 33.9 | 25, 26 | 4.9 | 5 | 16.1 | 29.0 |
| Parkersburg, W. Va. | 785 | 36 | 37.2 | 26 | 7.6 | 5 | 18.9 | 29.6 |
| Point Pleasant, W. Va. | 703 | 39 | 42.6 | 27 | 6.5 | 5 | 21.8 | 36.1 |
| Huntington, W. Va. | 660 | 50 | 46.7 | 27 | 10.2 | 6 | 26.0 | 36.5 |
| Catlettsburg, Ky. | 651 | 50 | 48.1 | 27 | 9.0 | 6 | 26.3 | 39.1 |
| Portsmouth, Ohio | 612 | 50 | 51.6 | 27 | 10.5 | 6 | 28.0 | 41.1 |
| Maysville, Ky. | 559 | 50 | 50.7 | 28 | 10.9 | 7 | 27.2 | 39.8 |
| Cincinnati, Ohio | 499 | 50 | 54.6 | 28 | 13.5 | 8 | 30.1 | 41.1 |
| Madison, Ind | 413 | 46 | 48.6 | 27 | 12.6 | 8 | 26.1 | 36.0 |
| Louisville, Ky. | 367 | 28 | 33.0 | 27 | 6.4 | 9 | 13.4 | 26.6 |
| Evansville, Ind. | 184 | 35 | 42.9 | 28 | 13.2 | 11 | 24.3 | 29.7 |
| Mount Vernon, Ind. (1) | 148 | 35 | 41.1 | 28 | 12.5 | 9, 11 | 23.2 | 28.6 |
| Paducah, Ky. | 47 | 40 | 41.0 | 28 | 11.6 | 1 | 23.3 | 29.4 |
| Cairo, Ill. | 1 | 45 | 43.9 | 28 | 17.3 | 1 | 27.9 | 26.6 |
| *Neosho River.* | | | | | | | | |
| Iola, Kans | 262 | 10 | 4.4 | 23 | — 2.2 | 16 | —0.5 | 6.6 |
| Oswego, Kans. | 184 | 20 | 6.4 | 25 | 0.4 | 1–6 | 1.7 | 6.0 |
| Fort Gibson, Okla. | 3 | 22 | 13.6 | 27, 28 | 10.0 | 8–13 | 11.5 | 3.6 |
| *Canadian River.* | | | | | | | | |
| Calvin, Okla. | 99 | 15 | 3.5 | 21 | 2.7 | 3, 16 | 3.1 | 0.8 |
| *Black River.* | | | | | | | | |
| Blackrock, Ark. | 67 | 12 | 14.5 | 28 | 4.9 | 11–13 | 9.2 | 9.6 |
| *White River.* | | | | | | | | |
| Calicorock, Ark | 272 | 18 | 11.1 | 24 | 1.6 | 10, 11 | 4.5 | 9.5 |
| Batesville, Ark. | 217 | 18 | 14.2 | 25 | 3.8 | 7, 8, 11–13 | 6.8 | 10.4 |
| Newport, Ark. | 185 | 26 | 21.0 | 28 | 5.0 | 5 | 11.4 | 16.0 |
| Clarendon, Ark. | 75 | 30 | 25.7 | 28 | 15.9 | 5 | 19.8 | 9.8 |
| *Arkansas River.* | | | | | | | | |
| Wichita, Kans | 832 | 10 | — 0.4 | 4, 5 | — 1.3 | 16 | —0.8 | 0.9 |
| Tulsa, Okla. | 551 | 16 | 2.8 | 27, 28 | 2.2 | 17–21 | 2.5 | 0.6 |
| Webbers Falls, Okla. | 465 | 23 | 8.8 | 27 | 5.6 | 10–12 | 7.0 | 3.2 |
| Fort Smith, Ark. | 403 | 22 | 10.6 | 23 | 5.6 | 5, 11, 12 | 7.1 | 5.0 |
| Dardanelle, Ark. | 256 | 21 | 10.7 | 24, 25 | 5.1 | 9 | 6.8 | 5.6 |
| Little Rock, Ark. | 176 | 23 | 11.8 | 26 | 4.8 | 5, 10 | 7.4 | 7.0 |
| *Yazoo River.* | | | | | | | | |
| Greenwood, Miss | 175 | 38 | 23.2 | 27 | 2.6 | 4 | 12.4 | 20.6 |
| Yazoo City, Miss. | 80 | 25 | 19.1 | 24 | 0.1 | 5–7 | 9.7 | 19.0 |
| *Ouachita River.* | | | | | | | | |
| Camden, Ark. | 304 | 39 | 28.0 | 19, 20 | 6.7 | 4 | 17.0 | 21.3 |
| Monroe, La. | 122 | 40 | 25.9 | 28 | 6.8 | 6 | 16.2 | 19.1 |
| *Red River* | | | | | | | | |
| Arthur City, Tex. | 688 | 27 | 7.0 | 25 | 6.4 | 12, 13, 15, 16, 27, 28 | 6.6 | 0.6 |
| Fulton, Ark. | 515 | 28 | 16.0 | 18 | 8.8 | 5, 6 | 11.4 | 7.2 |
| Shreveport, La. | 327 | 29 | 6.9 | 21 | 0.1 | 5 | 2.9 | 6.8 |
| Alexandria, La. | 118 | 36 | 14.1 | 24 | 3.9 | 5 | 8.4 | 10.2 |
| *Mississippi River* | | | | | | | | |
| Fort Ripley, Minn. (28) | 2,082 | 10 | ...... | ...... | ...... | ...... | ...... | ...... |
| St. Paul, Minn. (28) | 1,954 | 14 | ...... | ...... | ...... | ...... | ...... | ...... |
| Red Wing, Minn. (28) | 1,914 | 14 | ...... | ...... | ...... | ...... | ...... | ...... |

TABLE IV.—*Heights of rivers referred to zeros of gages*—Continued.

| Stations. | Distance to mouth of river. | Flood stage on gage. | Highest water. Height. | Highest water. Date. | Lowest water. Height. | Lowest water. Date. | Mean stage. | Monthly range. |
|---|---|---|---|---|---|---|---|---|
| *Mississippi River.*—Cont'd. | *Miles.* | *Feet.* | *Feet.* | | *Feet.* | | *Feet.* | *Feet.* |
| Reeds Landing, Minn. | 1,884 | 12 | 0.2 | 1-7 | 0.0 | 14-28 | 0.1 | 0.2 |
| La Crosse, Wis. (28) | 1 819 | 12 | ...... | ...... | ...... | ...... | ...... | ...... |
| Prairie du Chien, Wis. (28) | 1,759 | 18 | ...... | ...... | ...... | ...... | ...... | ...... |
| Dubuque, Iowa (28) | 1,699 | 18 | ...... | ...... | ...... | ...... | ...... | ...... |
| Clinton, Iowa (28) | 1,629 | 16 | ...... | ...... | ...... | ...... | ...... | ...... |
| Leclaire, Iowa (28) | 1,609 | 10 | ...... | ...... | ...... | ...... | ...... | ...... |
| Davenport, Iowa (6) | 1,593 | 15 | 11.0 | 1 | 5.4 | 9 | 7.7 | 5.6 |
| Muscatine, Iowa | 1,562 | 16 | 11.9 | 5 | 8.3 | 11 | 10.4 | 3.6 |
| Galland, Iowa | 1,472 | 8 | 4.8 | 4 | 1.3 | 1 | 2.8 | 3.5 |
| Keokuk, Iowa | 1,463 | 15 | 6.5 | 4 | 3.0 | 1 | 4.9 | 3.5 |
| Warsaw, Ill. (7) | 1,458 | 18 | 11.2 | 4 | 7.1 | 23 | 8.6 | 4.1 |
| Hannibal, Mo. | 1,402 | 13 | 7.3 | 6 | 0.8 | 3 | 5.2 | 6.5 |
| Grafton, Ill | 1,306 | 23 | 10.5 | 25 | 3.8 | 4 | 8.0 | 6.7 |
| St. Louis, Mo | 1,264 | 30 | 16.7 | 25 | 5.4 | 3 | 10.3 | 11.3 |
| Chester, Ill | 1,189 | 30 | 14.7 | 26 | 5.4 | 4 | 9.3 | 9.3 |
| Cape Girardeau, Mo. | 1,128 | 28 | 20.4 | 27 | 9.0 | 5,7 | 13.5 | 11.4 |
| New Madrid, Mo. | 1,003 | 34 | 34.9 | 28 | 14.3 | 1 | 22.4 | 20.6 |
| Memphis, Tenn | 843 | 33 | 31.8 | 28 | 11.9 | 3 | 19.1 | 19.9 |
| Helena, Ark. | 767 | 42 | 37.3 | 28 | 14.1 | 4 | 22.5 | 23.2 |
| Arkansas City, Ark. | 635 | 42 | 38.2 | 28 | 17.9 | 5,6 | 24.7 | 20.3 |
| Greenville, Miss. | 595 | 42 | 32.3 | 28 | 14.0 | 6 | 20.1 | 18.3 |
| Vicksburg, Miss. | 474 | 45 | 35.3 | 28 | 15.3 | 8,9 | 21.6 | 20.0 |
| Natchez, Miss. | 373 | 46 | 34.8 | 28 | 17.0 | 9 | 22.1 | 17.8 |
| Baton Rouge, La. | 240 | 35 | 24.6 | 28 | 10.9 | 9 | 14.7 | 13.7 |
| Donaldsonville, La | 188 | 28 | 18.6 | 28 | 7.4 | 8 | 10.3 | 11.2 |
| New Orleans, La. | 108 | 18 | 11.3 | 28 | 4.7 | 1 | 6.7 | 6.6 |
| *Atchafalaya River.* | | | | | | | | |
| Simmesport, La. | 127 | 41 | 30.3 | 28 | 13.4 | 1 | 19.1 | 16.9 |
| Melville, La. | 103 | 37 | 29.0 | 28 | 16.0 | 1 | 20.7 | 13.0 |
| Morgan City, La. * | 19 | 8 | 4.8 | 9 | 2.6 | 27,28 | 3.5 | 2.2 |
| *Hudson River.* | | | | | | | | |
| Troy, N. Y. | 154 | 14 | 22.5‡ | 21 | 5.7 | 1 | 9.4 | 16.8 |
| Albany, N. Y. | 147 | 12 | 17.9 | 21 | 3.9 | 3,4 | 6.8 | 14.0 |
| *Delaware River.* | | | | | | | | |
| Hancock (E. Branch), N. Y. | 287 | 12 | 11.1 | 20 | 3.5 | 1-3 | 5.3 | 7.6 |
| Hancock (W. Branch), N. Y. | 287 | 10 | 9.0 | 20 | 3.2 | 2 | 5.3 | 5.8 |
| Port Jervis, N. Y. | 215 | 14 | 11.7 | 21 | 2.8 | 3 | 5.9 | 8.9 |
| Phillipsburg, N. J. (2) | 146 | 26 | 16.6 | 21 | 2.0 | 4,5 | 6.8 | 14.6 |
| Trenton, N. J. | 92 | 18 | 9.8 | 21 | 2.2 | 4-8 | 4.8 | 7.6 |
| *North Branch Susquehanna.* | | | | | | | | |
| Binghamton, N. Y. | 183 | 14 | 12.4 | 21 | 2.8 | 1 | 6.2 | 9.6 |
| Wilkes-Barre, Pa. | 60 | 17 | 17.8 | 26 | 7.1 | 14 | 11.2 | 10.7 |
| *West Branch Susquehanna.* | | | | | | | | |
| Williamsport, Pa. | 39 | 20 | 14.5 | 25 | 1.8 | 2 | 6.7 | 12.7 |
| *Susquehanna River.* | | | | | | | | |
| Harrisburg, Pa. | 69 | 17 | 13.0 | 26 | 2.5 | 5 | 6.5 | 10.5 |
| *Shenandoah River.* | | | | | | | | |
| Riverton, Va. | 58 | 22 | 3.7 | 11 | 0.2 | 7-9 | 1.1 | 3.5 |
| *Potomac River.* | | | | | | | | |
| Cumberland, Md. | 290 | 8 | 5.8 | 24 | 2.9 | 6-10 | 3.8 | 2.9 |
| Harpers Ferry, W. Va. | 172 | 18 | 8.6 | 25 | 1.5 | 3-8 | 3.6 | 7.1 |
| *James River.* | | | | | | | | |
| Lynchburg, Va. | 260 | 20 | 7.2 | 11 | 1.5 | 6-8 | 3.2 | 5.7 |
| Columbia, Va. | 167 | 18 | 14.0 | 12 | 6.0 | 9 | 8.2 | 8.0 |
| Richmond, Va. | 111 | 10 | 4.3 | 13 | 0.8 | 7 | 1.9 | 3.5 |
| *Dan River.* | | | | | | | | |
| Danville, Va | 55 | 8 | 2.8 | 25 | 0.1 | 4,5 | 0.8 | 2.7 |
| *Roanoke River.* | | | | | | | | |
| Clarksville, Va | 196 | 12 | 5.0 | 25 | 0.7 | 3 | 2.1 | 4.3 |
| Weldon, N. C. | 129 | 30 | 25.1 | 26 | 11.3 | 4 | 14.8 | 13.8 |
| *Tar River.* | | | | | | | | |
| Greenville, N. C. | 21 | 22 | 11.8 | 28 | 5.0 | 6-8 | 7.4 | 6.8 |
| *Haw River.* | | | | | | | | |
| Moncure, N. C. | 171 | 25 | 14.6 | 11 | 7.8 | 4,5 | 9.3 | 6.8 |
| *Cape Fear River.* | | | | | | | | |
| Fayetteville, N. C. | 112 | 38 | 23.0 | 12 | 5.0 | 5 | 11.4 | 18.0 |
| *Pedee River.* | | | | | | | | |
| Cheraw, S. C. | 149 | 27 | 21.2 | 11 | 3.3 | 5 | 7.8 | 17.9 |
| Smiths Mills, S. C. | 51 | 16 | 11.9 | 20 | 5.3 | 8 | 9.0 | 6.6 |
| *Lynch Creek.* | | | | | | | | |
| Effingham, S. C. | 35 | 12 | 10.3 | 26 | 4.0 | 3-5 | 6.4 | 6.3 |
| *Black River.* | | | | | | | | |
| Kingstree, S. C. | 45 | 12 | 7.0 | 24 | 2.2 | 5-9 | 4.3 | 4.8 |
| *Catawba-Wateree River.* | | | | | | | | |
| Mount Holly, N. C. | 143 | 15 | 3.0 | 24 | 2.0 | 1-9, 13-19, 21, 28 | 2.2 | 1.0 |
| Catawba, S. C | 107 | 11 | 6.8 | 11 | 2.4 | 6 | 4.3 | 4.4 |
| *Catawba-Wateree River*—Con | *Miles.* | *Feet.* | *Feet.* | | *Feet.* | | *Feet.* | *Feet.* |
| Camden, S. C. | 37 | 24 | 23.5 | 11 | 6.5 | 7 | 11.9 | 17.0 |
| *Congaree River.* | | | | | | | | |
| Columbia, S. C | 52 | 15 | 14.0 | 11 | 1.6 | 2 | 4.2 | 12.4 |
| *Santee River.* | | | | | | | | |
| Ferguson, S. C. | 82 | 12 | 13.5 | 16-18 | 9.4 | 4-6 | 11.9 | 4.1 |
| *Savannah River.* | | | | | | | | |
| Calhoun Falls, S. C. | 347 | 15 | 7.0 | 23 | 2.6 | 5 | 4.2 | 4.4 |
| Augusta, Ga. | 268 | 32 | 27.8 | 11 | 8.9 | 3 | 15.4 | 18.9 |
| *Oconee River.* | | | | | | | | |
| Dublin, Ga | 79 | 30 | 15.9 | 16 | 1.6 | 3-6 | 8.8 | 14.3 |
| *Ocmulgee River.* | | | | | | | | |
| Macon, Ga. | 134 | 18 | 18.2 | 10 | 2.6 | 2 | 9.9 | 15.6 |
| Abbeville, Ga. | 51 | 11 | 13.6 | 18 | 3.0 | 5,6 | 8.8 | 10.6 |
| *Flint River.* | | | | | | | | |
| Montezuma, Ga. | 152 | 20 | 16.7 | 13 | 3.5 | 3-5 | 10.0 | 13.2 |
| Albany, Ga. | 99 | 20 | 16.0 | 18 | 1.3 | 9 | 7.9 | 14.7 |
| Bainbridge, Ga. | 22 | 22 | 15.9 | 24 | 4.7 | 5-8 | 10.2 | 11.2 |
| *Chattahoochee River.* | | | | | | | | |
| Oakdale, Ga. | 305 | 18 | 19.0 | 23 | 5.0 | 4 | 10.6 | 14.0 |
| West Point, Ga | 174 | 20 | 14.2 | 16,17 | 3.0 | 1,2,4,5 | 7.4 | 11.2 |
| Eufaula, Ala | 90 | 40 | 30.0 | 11,12 | 2.9 | 5 | 14.2 | 27.1 |
| Alaga, Ala. | 30 | 25 | 27.9 | 18 | 3.8 | 3-6 | 14.7 | 24.1 |
| *Coosa River.* | | | | | | | | |
| Rome, Ga. | 266 | 30 | 22.1 | 23 | 1.5 | 3-5 | 10.8 | 20.6 |
| Gadsden, Ala. | 162 | 22 | 19.7 | 18,26 | 2.3 | 5 | 12.6 | 17.4 |
| Lock No. 4, Ala. | 113 | 17 | 16.1 | 16 | 1.9 | 4-6 | 10.0 | 14.2 |
| Wetumpka, Ala | 12 | 45 | 35.3 | 17 | 4.1 | 5 | 20.0 | 31.2 |
| *Alabama River.* | | | | | | | | |
| Montgomery, Ala. | 323 | 35 | 33.4 | 17,18 | 2.3 | 5 | 17.6 | 31.1 |
| Selma, Ala | 246 | 35 | 38.9 | 19 | 2.5 | 5 | 20.8 | 36.4 |
| *Black Warrior River.* | | | | | | | | |
| Tuscaloosa, Ala. | 90 | 43 | 48.3 | 16 | 7.0 | 5 | 28.0 | 41.3 |
| *Tombigbee River.* | | | | | | | | |
| Columbus, Miss | 316 | 33 | 22.0 | 28 | — 1.2 | 5 | 12.1 | 23.2 |
| Demopolis, Ala. | 168 | 35 | 46.7 | 28 | 3.6 | 5 | 26.6 | 43.1 |
| *Pascagoula River.* | | | | | | | | |
| Merrill, Miss. | 78 | 20 | 12.8 | 21 | 1.4 | 2-6 | 6.8 | 11.4 |
| *Pearl River.* | | | | | | | | |
| Columbia, Miss. | 110 | 18 | 15.4 | 28 | 3.7 | 5 | 9.7 | 11.7 |
| *Sabine River.* | | | | | | | | |
| Logansport, La. | 315 | 25 | 19.0 | 19,20 | 3.3 | 2,3 | 10.4 | 15.7 |
| *Neches River.* | | | | | | | | |
| Beaumont, Tex | 18 | 10 | 2.2 | 23 | 0.2 | 4 | 1.1 | 2.0 |
| *Trinity River.* | | | | | | | | |
| Dallas, Tex. | 320 | 25 | 10.4 | 22 | 4.5 | 3,4 | 6.7 | 5.9 |
| Long Lake, Tex. | 211 | 40 | 3.0 | 28 | 1.0 | 7-9 | 1.6 | 2.0 |
| Liberty, Tex | 20 | 25 | 9.1 | 19,20 | 4.6 | 1,2 | 6.0 | 4.5 |
| *Brazos River.* | | | | | | | | |
| Waco, Tex. | 285 | 24 | 1.5 | 16,17 | 1.1 | 9,10 | 1.3 | 0.4 |
| Hempstead, Tex | 140 | 40 | 1.7 | 18,20 | — 0.2 | 6 | 0.6 | 1.9 |
| Booth, Tex | 61 | 39 | 3.3 | 1-9 | 2.5 | 23-28 | 3.0 | 0.8 |
| *Colorado River.* | | | | | | | | |
| Austin, Tex | 214 | 18 | 1.5 | 15 | 0.9 | 27,28 | 1.2 | 0.6 |
| Columbus, Tex. | 98 | 24 | 5.9 | 1-8, 15-18 | 5.7 | 26-28 | 5.8 | 0.2 |
| *Red River of the North.* | | | | | | | | |
| Moorhead, Minn. (28) | 284 | 26 | ...... | ...... | ...... | ...... | ...... | ...... |
| *Snake River.* | | | | | | | | |
| Lewiston, Idaho | 144 | 24 | 6.0 | 18 | 2.4 | 12 | 3.6 | 3.6 |
| Riparia, Wash. | 67 | 30 | 5.6 | 10-12, 14-18, 20 | 5.0 | 28 | 5.4 | 0.6 |
| *Columbia River.* | | | | | | | | |
| Wenatchee, Wash | 473 | 40 | 7.8 | 1,2 | 6.7 | 18-22 | 7.1 | 1.1 |
| Umatilla, Oreg | 270 | 25 | 3.8 | 19 | 2.1 | 12 | 2.9 | 1.7 |
| The Dalles, Oreg. † | 166 | 40 | 7.8 | 21 | 2.7 | 15 | 4.6 | 5.1 |
| *Willamette River.* | | | | | | | | |
| Albany, Oreg. | 118 | 20 | 13.3 | 18,19 | 5.7 | 2 | 10.5 | 7.6 |
| Portland, Oreg. | 12 | 15 | 11.6 | 20 | 4.5 | 14 | 7.4 | 7.1 |
| *Sacramento River.* | | | | | | | | |
| Red Bluff, Cal. | 265 | 23 | 30.5 | 3 | 9.4 | 28 | 15.8 | 21.1 |
| Colusa, Cal. | 156 | 28 | 27.4 | 5 | 19.8 | 28 | 22.8 | 7.6 |
| Knights Landing, Cal. | 99 | 18 | 18.8 | 6 | 17.6 | 27,28 | 18.0 | 1.2 |
| Sacramento, Cal. | 64 | 25 | 24.0 | 13 | 21.1 | 28 | 22.6 | 2.9 |
| *San Joaquin River.* | | | | | | | | |
| Pollasky, Cal. | 203 | 10 | 5.3 | 12 | 0.9 | 2,3 | 1.7 | 4.4 |
| Firebaugh, Cal | 148 | 14 | 10.1 | 14 | 4.4 | 4 | 6.4 | 5.7 |
| Lathrop, Cal. | 49 | 14 | 18.2 | 15 | 15.0 | 28 | 16.4 | 3.2 |

*9 days missing. † 3 days missing. ‡ Due to ice gorge near Albany, N. Y. Figures in parenthesis represent number of days river was frozen during the month.

12——6

*Honolulu, T. H., latitude 21° 19′ north, longitude 157° 52′ west; barometer above sea, 38 feet; gravity correction, —0.057 inch, applied. February, 1909.*

| Day. | Pressure, in inches.* | | Air temperature, degrees Fahrenheit. | | | | Moisture. | | | | Wind, in miles per hour. | | | | Precipitation, inches. | | Clouds. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 8 a. m. | | 8 p. m. | | 8 a. m. | | 8 p. m. | | | | 8 a. m. | | | 8 p. m. | | |
| | 8 a. m. | 8 p. m. | 8 a. m. | 8 p. m. | Maximum. | Minimum. | Wet. | Relative humidity. | Wet. | Relative humidity. | Direction. | Velocity. | Direction. | Velocity. | 8 a. m. | 8 p. m. | Amount. | Kind. | Direction, from. | Amount. | Kind. | Direction, from. |
| | | | | | | | ° | % | ° | % | | | | | | | | | | | | |
| 1 | 30.10 | 30.08 | 65.0 | 69.5 | 72 | 64 | 62.0 | 85 | 62.0 | 66 | e. | 3 | e. | 10 | T. | 0.03 | 10 | N. | e. | 9 | Cu. | ne. |
| 2 | 30.08 | 30.01 | 69.5 | 69.5 | 74 | 66 | 61.0 | 61 | 62.5 | 68 | ne. | 12 | ne. | 10 | 0.00 | 0.00 | 7<br>3 | Ci.-s.<br>S.-cu. | sw.<br>e. | 5<br>5 | A.-cu.<br>Cu. | nw.<br>ne. |
| 3 | 30.05 | 30.02 | 70.0 | 69.0 | 75 | 68 | 61.3 | 60 | 64.0 | 76 | ne. | 9 | e. | 9 | 0.00 | 0.00 | 6<br>Few | Ci.-cu.<br>Cu. | sw.<br>e. | 10 | S. | ne. |
| 4 | 29.99 | 29.95 | 67.0 | 68.0 | 71 | 64 | 64.3 | 86 | 64.0 | 80 | ne. | 5 | ne. | 2 | 0.12 | T. | 10 | N. | n. | 10 | S. | ne. |
| 5 | 29.92 | 29.88 | 67.5 | 70.0 | 74 | 64 | 64.4 | 85 | 66.0 | 81 | ne. | 4 | ne. | 4 | 0.00 | 0.00 | 1<br>6<br>......<br>...... | Ci.-s.<br>A.-s.<br>......<br>Lt. smoke | 0(?)<br>ne.<br>......<br>0 | 4<br>1<br>1<br>4 | A.-s.<br>S.-cu.<br>Cu.<br>S. | w.<br>e.<br>e.<br>e. |
| 6 | 29.88 | 29.86 | 70.0 | 67.0 | 74 | 64 | 66.0 | 81 | 62.0 | 75 | e. | 3 | e. | 9 | 0.02 | 0.86 | 10 | S. | sw. | 10 | N. | e. |
| 7 | 29.86 | 29.87 | 71.0 | 66.0 | 74 | 64 | 66.0 | 77 | 63.5 | 87 | se. | 3 | n. | 9 | 0.01 | 0.20 | Few | Cu. | se. | 8 | N. | ne. |
| 8 | 29.91 | 29.94 | 68.4 | 67.0 | 74 | 62 | 63.2 | 75 | 64.0 | 85 | e. | 1 | n. | 4 | T. | 0.00 | ...... | Lt. smoke | 0 | ...... | Lt. smoke | 0 |
| 9 | 29.96 | 29.95 | 70.0 | 69.0 | 74 | 62 | 63.5 | 70 | 64.5 | 79 | n. | 2 | ne. | 4 | 0.00 | 0.00 | Few<br>... | Cu.<br>Lt. smoke | ne.<br>0 | 0 | 0 | 0 |
| 10 | 30.00 | 29.98 | 69.0 | 68.0 | 74 | 62 | 63.2 | 73 | 63.0 | 76 | ne. | 3 | ne. | 4 | 0.00 | 0.00 | Few | Cu. | 0(?) | 0 | 0 | 0 |
| 11 | 29.98 | 29.94 | 68.0 | 70.5 | 74 | 62 | 63.0 | 76 | 65.0 | 74 | ne. | 1 | sw. | 6 | 0.00 | 0.00 | ...... | Lt. smoke | 0 | 0 | 0 | 0 |
| 12 | 29.90 | 29.97 | 72.2 | 64.0 | 75 | 56 | 66.1 | 73 | 62.0 | 90 | sw. | 22 | nw. | 3 | 0.36 | 0.32 | 6 | S.-cu. | w. | 10 | N. | n. |
| 13 | 30.01 | 30.03 | 69.2 | 65.0 | 73 | 59 | 62.0 | 66 | 59.0 | 70 | n. | 3 | ne. | 8 | 0.09 | 0.00 | Few | A.-cu. | 0 | 0 | 0 | 0 |
| 14 | 30.08 | 30.10 | 66.0 | 69.0 | 74 | 62 | 60.2 | 72 | 64.0 | 76 | w. | 2 | e. | 2 | 0.00 | 0.00 | 9<br>...... | A.-cu.<br>Lt. smoke | s.<br>0 | Few | S. | e. |
| 15 | 30.12 | 30.12 | 71.1 | 69.0 | 74 | 64 | 64.8 | 71 | 66.0 | 85 | ne. | 1 | se. | 3 | 0.00 | 0.00 | ...... | Lt. smoke | 0 | 0 | 0 | 0 |
| 16 | 30.20 | 30.21 | 74.0 | 70.5 | 75 | 66 | 68.0 | 74 | 67.0 | 84 | e. | 3 | ne. | 3 | 0.00 | 0.00 | Few<br>Few<br>...... | A.-cu.<br>Cu.<br>Lt. smoke | s.<br>0<br>0 | 7 | S. | nw. |
| 17 | 30.26 | 30.24 | 71.0 | 71.0 | 76 | 67 | 65.1 | 73 | 66.0 | 77 | ne. | 13 | ne. | 9 | 0.01 | 0.00 | 4<br>4 | A.-cu.<br>S.-cu. | se.<br>n. | 7 | S. | w. |
| 18 | 30.26 | 30.18 | 71.0 | 72.0 | 77 | 68 | 62.0 | 60 | 67.0 | 77 | e. | 16 | ne. | 24 | 0.00 | 0.00 | Few | Cu. | 0 | 0 | 0 | 0 |
| 19 | 30.16 | 30.12 | 73.1 | 72.0 | 77 | 69 | 65.0 | 65 | 65.0 | 69 | e. | 22 | e. | 12 | 0.00 | 0.00 | Few | Cu. | e. | 0 | 0 | 0 |
| 20 | 30.14 | 30.08 | 72.3 | 71.0 | 78 | 70 | 65.0 | 68 | 67.0 | 81 | e. | 6 | ne. | 4 | 0.00 | 0.00 | 7 | S.-cu. | e. | 0 | 0 | 0 |
| 21 | 30.16 | 30.15 | 73.0 | 72.5 | 78 | 66 | 67.0 | 73 | 66.0 | 71 | ne. | 7 | ne. | 8 | 0.07 | 0.00 | Few<br>4<br>Few | A.-cu.<br>S.-cu.<br>Cu. | 0(?)<br>e.<br>0(?) | 4 | Cu. | ne. |
| 22 | 30.16 | 30.14 | 72.0 | 72.0 | 78 | 68 | 65.1 | 69 | 63.5 | 63 | ne. | 6 | ne. | 10 | T. | 0.04 | 2<br>6 | Ci.-s.<br>S.-cu. | 0(?)<br>ne. | 3 | Cu. | ne. |
| 23 | 30.20 | 30.13 | 70.2 | 71.0 | 75 | 63 | 64.0 | 71 | 64.0 | 68 | e. | 6 | ne. | 14 | 0.14 | 0.00 | Few<br>5 | Ci.-s.<br>S.-cu. | 0<br>e. | 0 | 0 | 0 |
| 24 | 30.16 | 30.15 | 71.1 | 71.0 | 76 | 64 | 64.2 | 68 | 64.0 | 68 | e. | 12 | ne. | 22 | 0.17 | T. | 1<br>5 | Ci.-s.<br>S.-cu. | 0(?)<br>ne. | 6 | Cu. | ne. |
| 25 | 30.20 | 30.21 | 71.0 | 70.0 | 74 | 69 | 63.0 | 64 | 63.0 | 68 | ne. | 22 | ne. | 12 | 0.00 | 0.00 | 6<br>4 | A.-cu.<br>S.-cu. | 0<br>ne. | 5 | Cu. | ne. |
| 26 | 30.18 | 30.16 | 68.0 | 70.0 | 73 | 64 | 63.0 | 76 | 54.0 | 72 | ne. | 18 | e. | 10 | T. | 0.09 | 2<br>6<br>2 | Ci.-cu.<br>S.-cu.<br>N. | 0(?)<br>e.<br>e. | 1<br>5<br>3 | A.-s.<br>Cu.<br>N. | w.<br>e.<br>ne. |
| 27 | 30.19 | 30.16 | 72.0 | 70.0 | 74 | 63 | 63.0 | 67 | 64.0 | 72 | e. | 16 | e. | 10 | 0.03 | 0.05 | 2<br>7 | Ci.-cu.<br>S.-cu. | 0<br>e. | 8<br>5 | Cu.<br>S. | ne.<br>ne. |
| 28 | 30.16 | 30.12 | 69.2 | 65.5 | 72 | 64 | 60.0 | 58 | 62.0 | 82 | ne. | 13 | e. | 12 | 0.01 | T. | 8 | S.-cu. | ne. | 5 | N. | ne. |
| Mean | 30.081 | 30.062 | 70.0 | 69.2 | 74.6 | 64.4 | 63.8 | 71.3 | 64.1 | 75.7 | ne. | 8.4 | ne. | 8.5 | 1.03 | 1.59 | 5.1 | S.-cu. | e. | 4.9 | Cu. | ne. |

Observations are made at 8 a.m. and 8 p. m., local standard time, which is that of 157° 30′ west, and is $5^h$ and $30^m$ slower than 75th meridian time. *Pressure values are reduced to sea level and standard gravity.

Chart I. Hydrographs for Seven Principal Rivers of the United States, February, 1909.

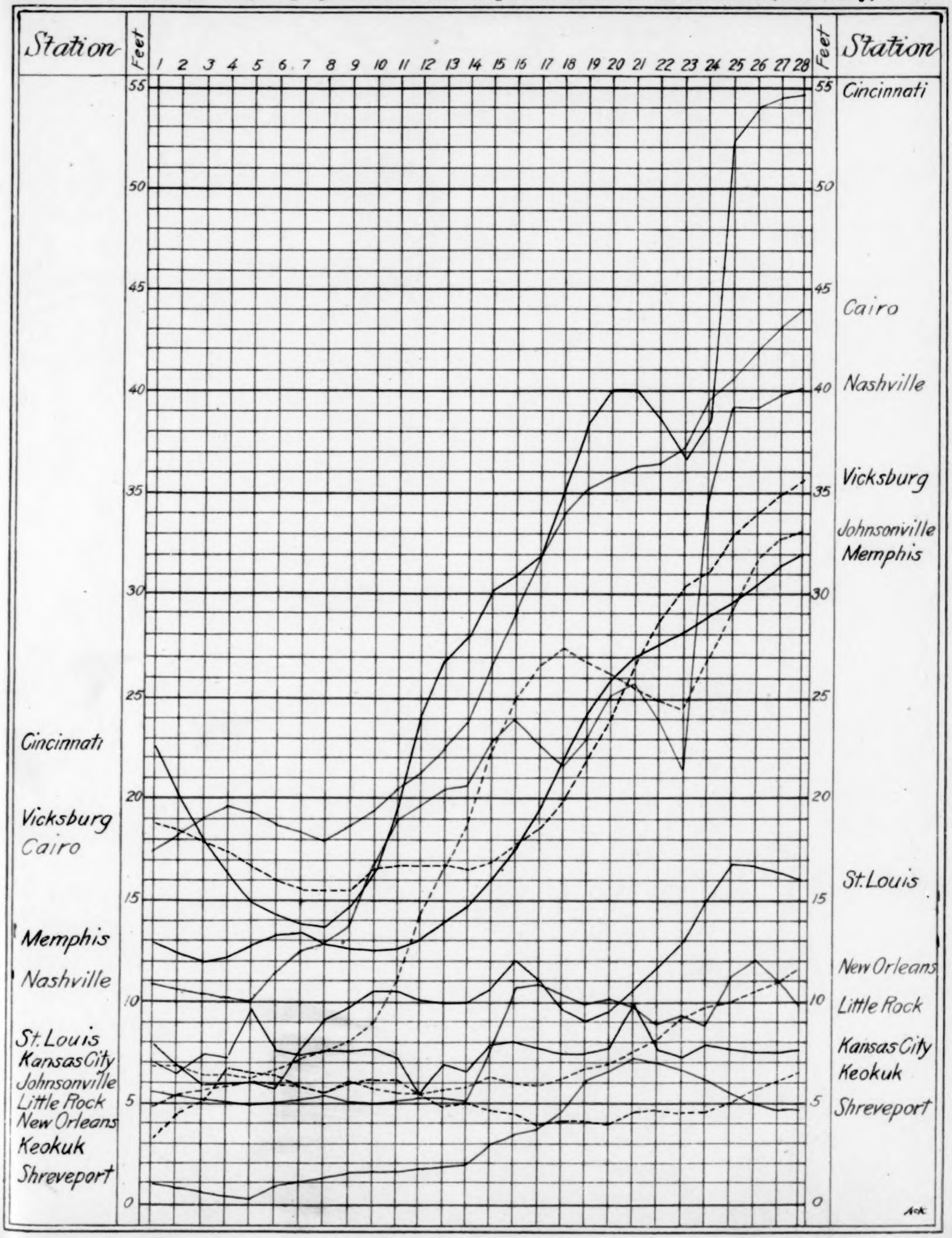


Chart II. Tracks of Centers of High Areas, February, 1909.

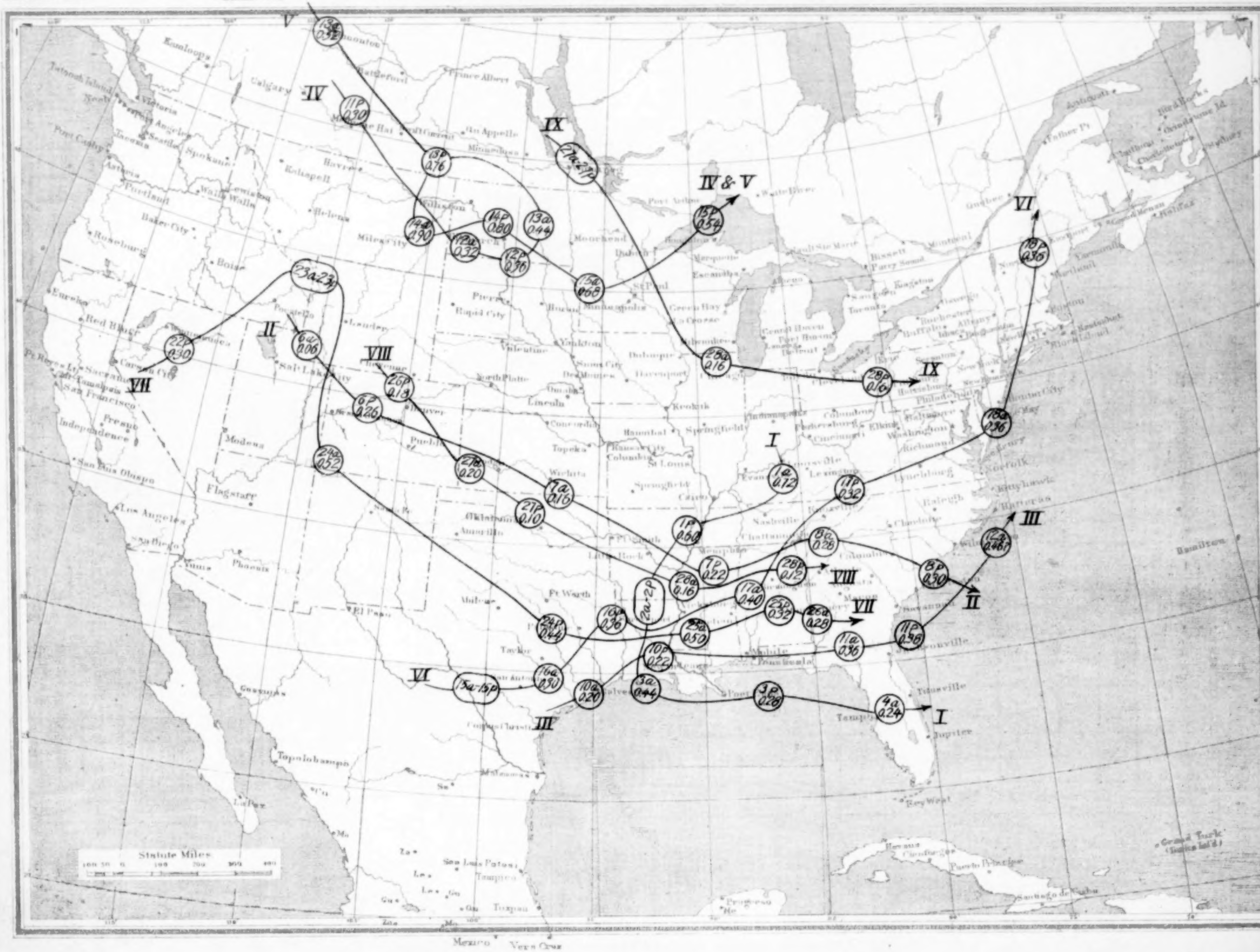
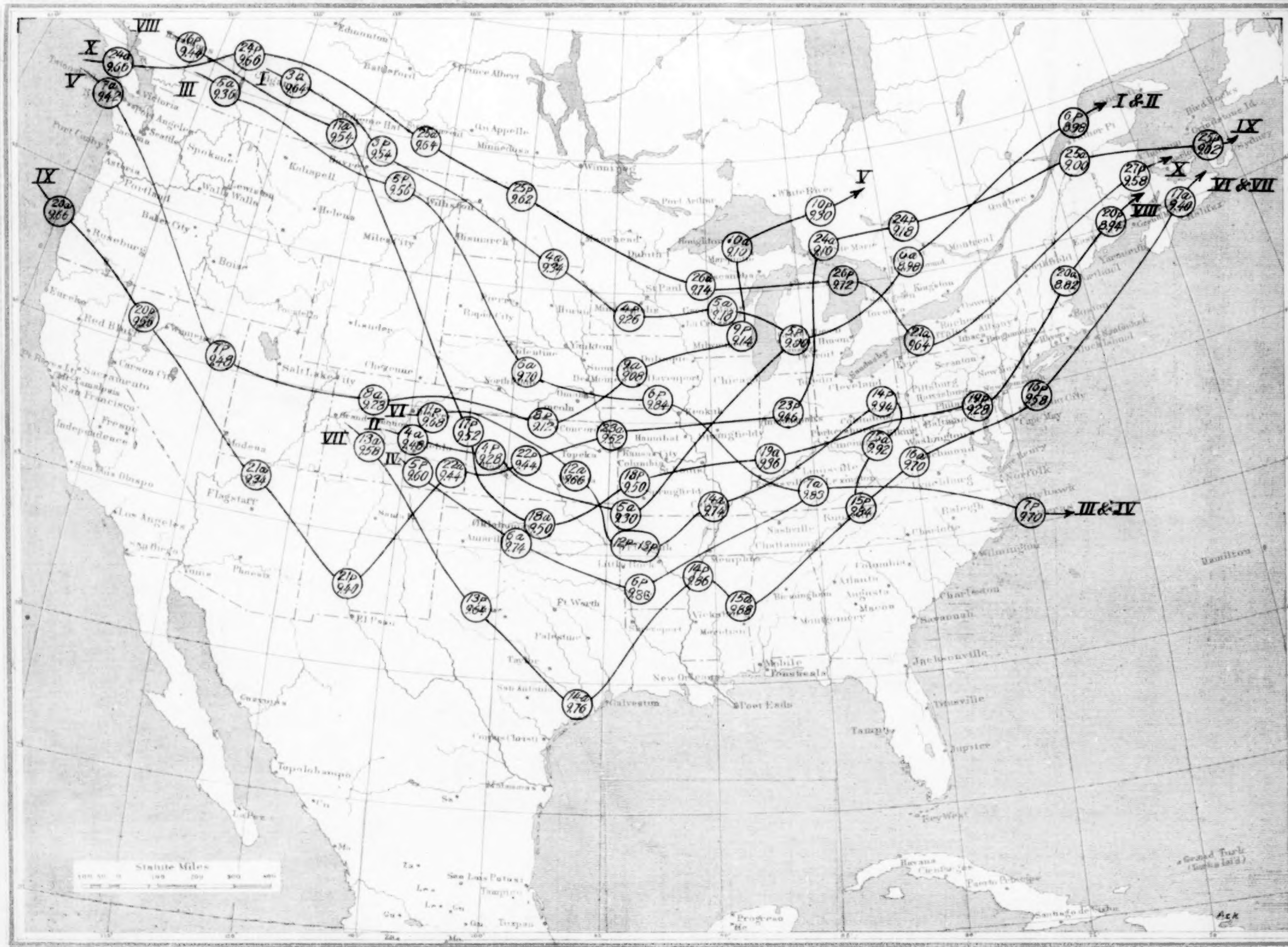


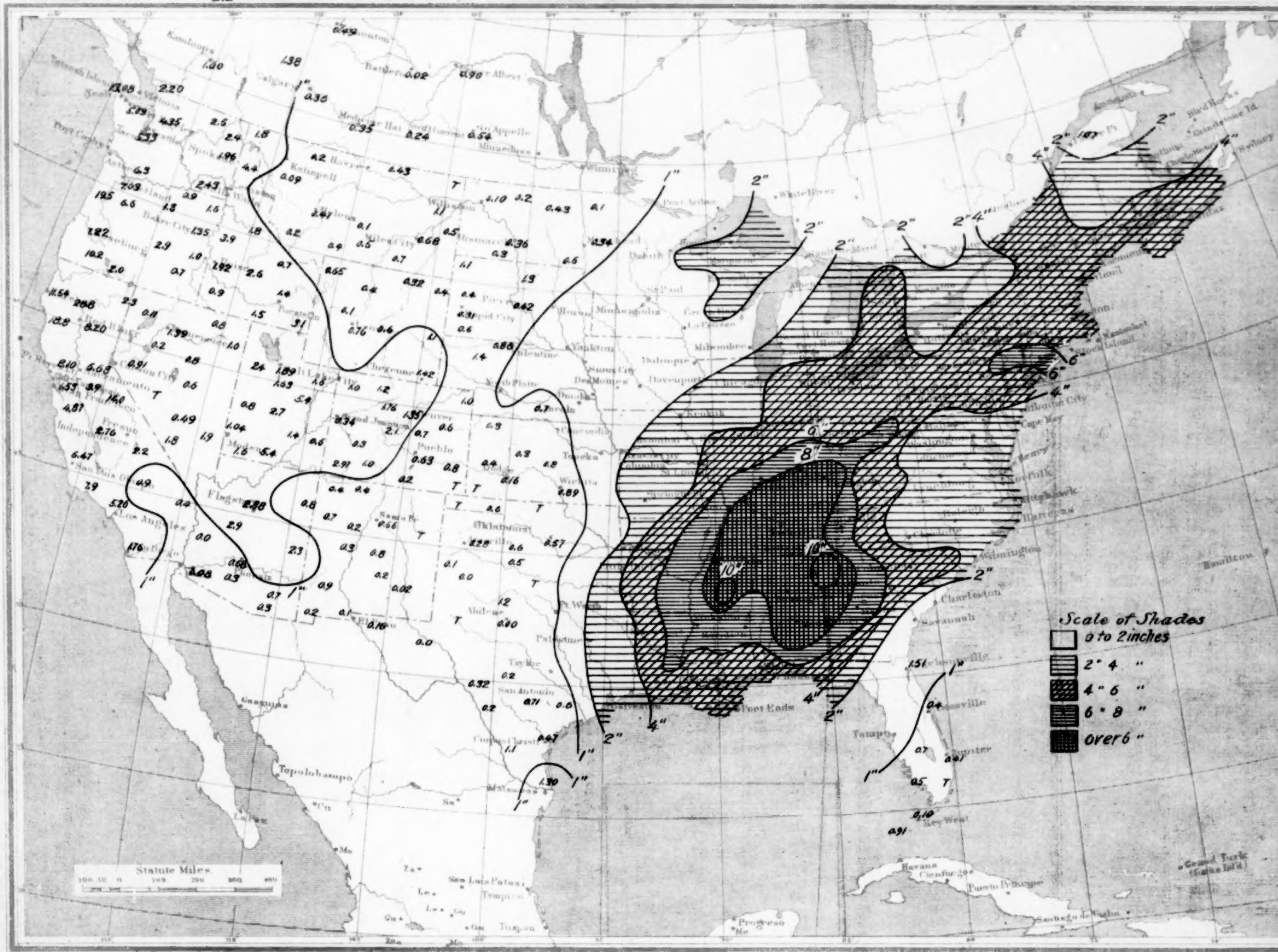



Chart III. Tracks of Centers of Low Areas, February, 1909.

Chart III. Tracks of Centers of Low Areas, February, 1909.



## Chart IV. Total Precipitation, February, 1909.






## Chart V. Percentage of Clear Sky between Sunrise and Sunset, February, 1909.

## Chart V. Percentage of Clear Sky between Sunrise and Sunset, February, 1909.

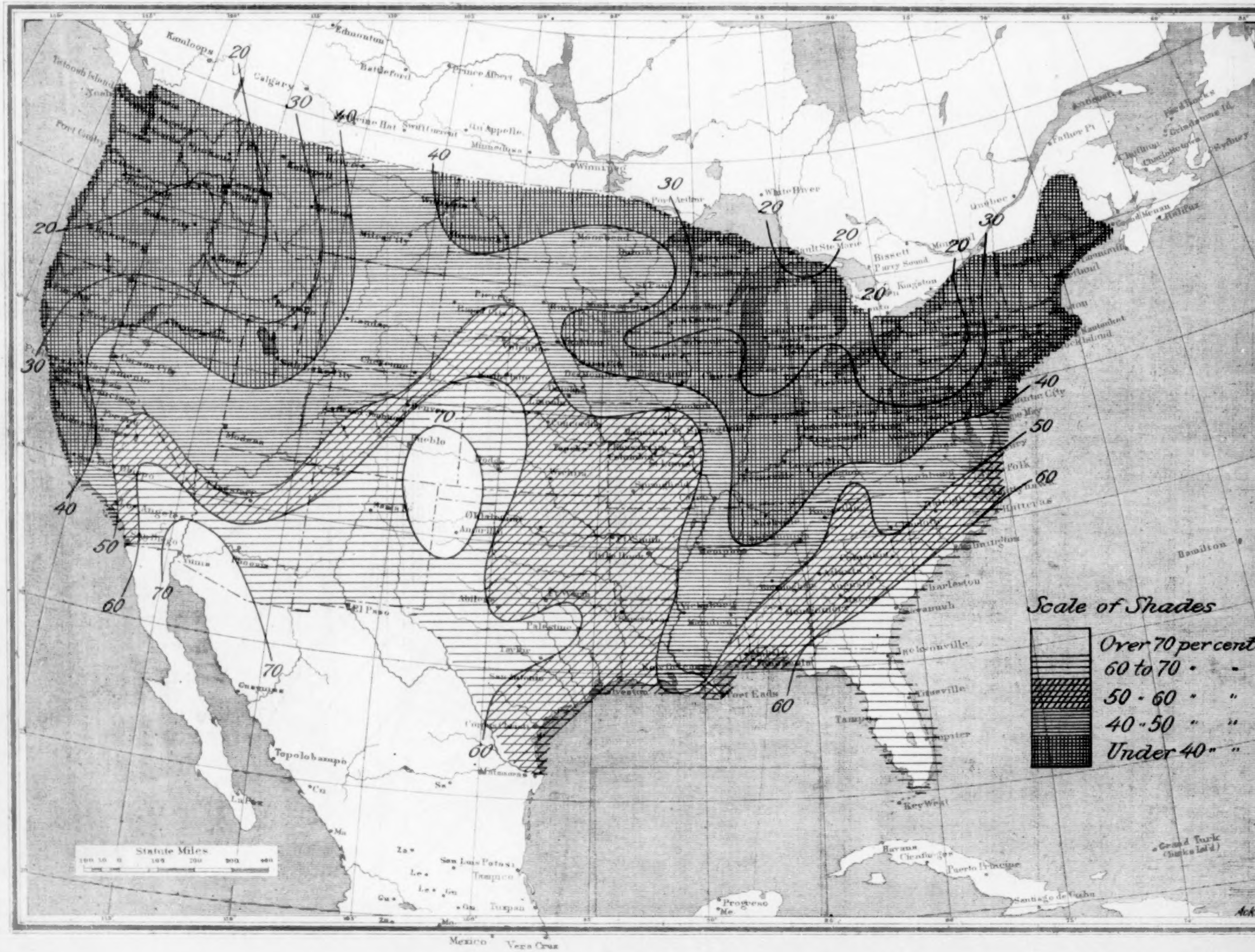


Chart VI. Isobars and Isotherms at Sea Level; Prevailing Winds, February, 1909.

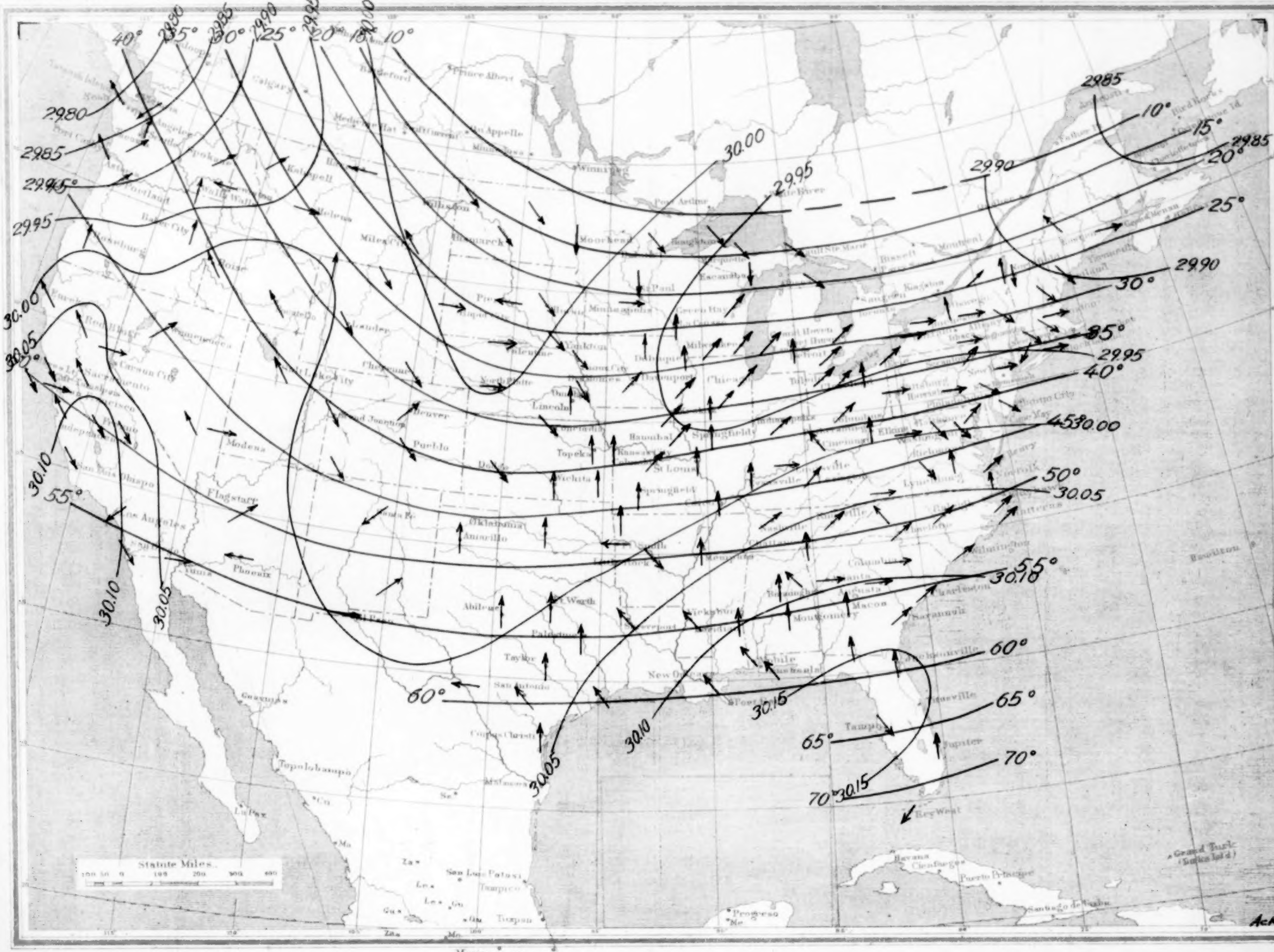
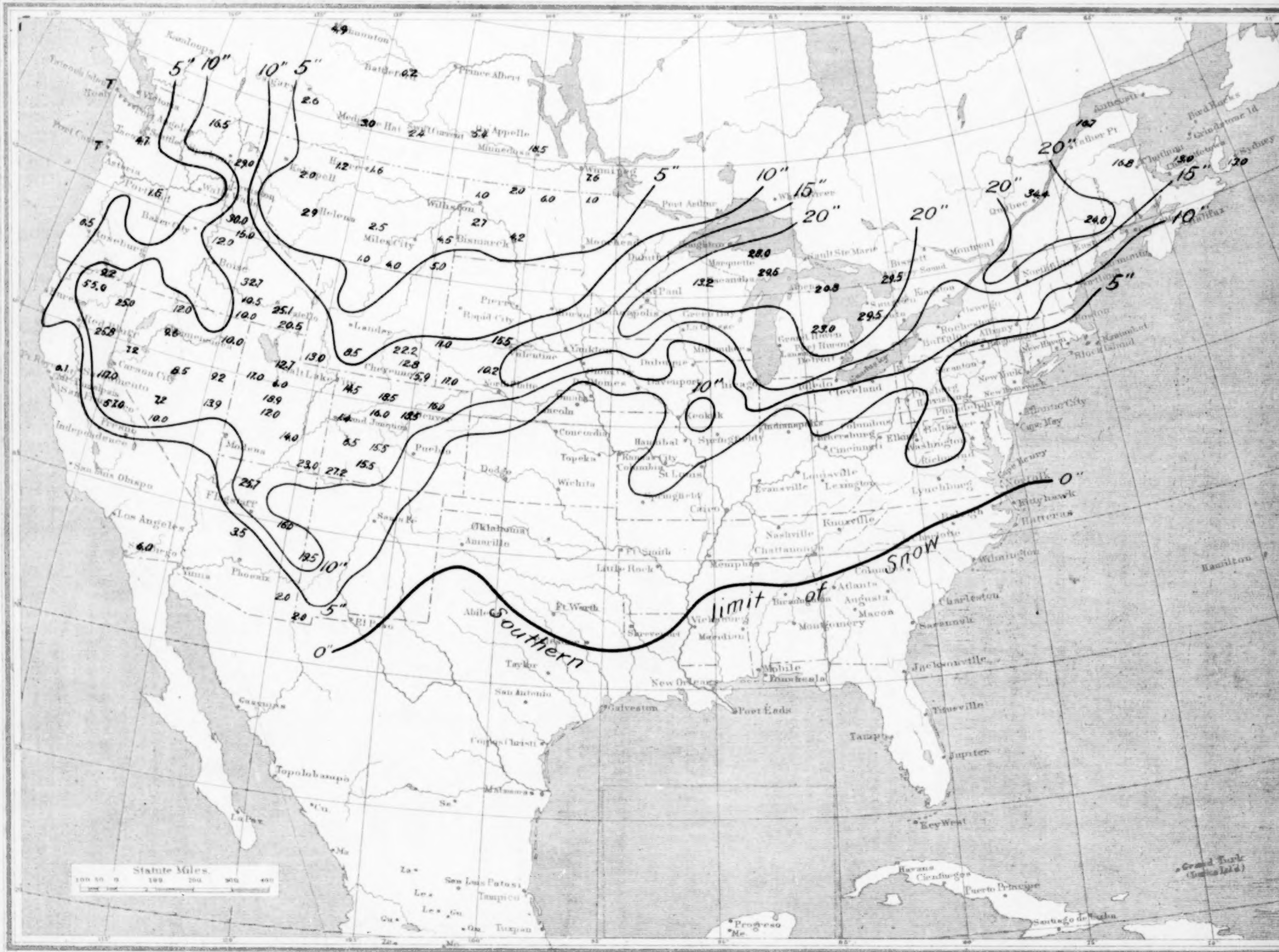





Chart VII. Total Snowfall for February, 1909.

Chart VII. Total Snowfall for February, 1909.




Mexico Vera Cruz

## Chart VIII. Depth of Snow on Ground, February 28, 1909.